Hans Jürgen Holstein

HOMO CYBERNETICUS 1

The Simulation of Everyday Life: A Synopsis

UPPSALA: SOCIOGRAFICA, 1974

Homo Cyberneticus

Akademisk avhandling

som med vederbörligt tillstånd
av Samhällsvetenskapliga Fakulteten vid Uppsala
Universitet för vinnande av filosofie doktorsgraden
framlägges till offentlig granskning å
universitetets lärosal IV
tisdagen den 21 maj 1974, kl 10.00

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"Mankind is continuously threatened by two things: Chaos and Order."

Pierre Schaeffer

"Without deviance there is no progress."

Frank Zappa

Hans Jürgen Holstein

Homo Cyberneticus

Volume 1:

The Simulation of Everyday Life: A Synopsis

Uppsala: Sociografica 1974

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Preface

Homo Cyberneticus comprises five volumes. All are relatively self-contained, but complement each other into one whole. The *first* volume is a synopsis of the simulation intentions and approach adopted by us; its tacit main question is "How can we operationalize these intangibilities?". The *second* volume tackles this problem on the methodological level by trying to elaborate a systematic epistemology for dynamic causal modelling. Its conclusions support our initial 'hunch' that simulation is the optimal tool for dymanic causal modelling. Volume *Three* is therefore an investigation into our possibilities of constructing a simulation tool (a computer program) which will allow us to concentrate on our problem instead of on the computer. We do not wish to adapt our problem to the computer, but expect the computer to adapt to our problem instead, so to speak. Volume *Four* leaves all computer problems behind and asks again how we can simulate human behavior; the investigaiton is this time less superficial than in the explorative first volume. The *fifth* volume, finally, delineates a framework for rendering the causal simulation of societal macro-processes possible. It is simultaneously a first example of how the principles discussed in the earlier volumes can constrain, generate, and guide large-model concretizations.

The tackled task is vast, and although everyone agrees that it needs be tackled, there seems to be a general suspicion that those who do it are charlatans and/or self-appointed prophets. It has hitherto been difficult to argue for *Homo Cyberneticus* properly because its 'point' lies in the linking together of a plurality of diverse fields of research, and also because it contains relatively much 'New Think'. Especially the advocation of commonsense thinking at the expense of statistics has evoked skepsis and territoriality defenses. Sociologists have thus downgraded it all to 'mere' computer science, while computer scientists have considered the simulation project oddly humanistic and too problem-oriented.

I was therefore very grateful when the Swedish Riksbank Tercentenary Fund dared to give financial support to my research in 1968. It has done so until this day.

The other important event was the foundation of the Computer Science Laboratory in Uppsala by Dr. Erik Sandewall and myself, as a 'home' for our up to then 'homeless' research projects, his being in the field of artificial intelligence, mine in sociocybernetics. This symbiosis has, at least for my part, been immensely stimulating.

I thank also my collegues *Lennart Stålberg, Torgny Tholerus, Tore Risch,* and *René Reboh,* most sincerely for their participation and cooperation in this sociocybernetics venture during the past years.

Uppsala, in April 1974 H.J.H.

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1. Introduction: The Perspective

1.1. The Human Condition

We 'understand' reality only to the extent to which we can model it. We wish to understand the world around us and within us in order to be able to predict its behavior and to learn how to manipulate it. Such abilities are necessary for coping with life and reality as a human being; a trivial device such as a tick needs to understand much less of its world in order to cope with it in a tick's style (Landmann 1964, p 170; Uexküll 1973, p 187 ff; Habermas 1958, p 32). Humans seek therefore to accumulate 'wisdom', principles which they believe to somehow govern man's manifest and inner, psychic behavior, and reality in general, and they try to order them into coherent models.

Ancient texts (such as Gilgamesch Epic, Hammurabi's laws, the epics of Homerus, Plato's Dialogues, or the Popol Vuh) and the comparative study of native cultures on all continents suggest that our modern societies are not essentially different from earlier societies except with respect to technology and knowledge about Nature, and that man's everyday behavior and emotional reaction pattern has remained almost invariant over at least five millenia. We are not as unique as we often tend to believe, and neither are our problems. We find throughout documented history that the individual man's two 'antagonists', Nature and society, have troubled him and motivated him to theorize about them (cf. Hofstätter 1969, 1959, p 32–55).

But while we have learned to regulate against Nature quite well, we have not managed to cope with the social problems that already existed 200 generations ago; we have presumably even added new ones. The social sciences grope for conceptions and theories of man and society that can suggest solutions.

But social science cannot solve social problems because theories cannot change reality. Conceptions and theories can only *guide* and *motivate* political action, not substitute it.

In almost all social situations there are some who happen to be favored and some who happen to be disfavored. It is 'natural' that those who are favored tend to resist situation changes, while the disfavored aspire changes. Those who aspire changes, however, are split into interest

categories; not all shifts are improvements for each of these.

Since social reality is complex and unsurveillable, people need to rely on information from other people about current social circumstances. It is thus possible to *misguide* people in such a manner that they *believe* to act to their own advantages, while they in fact act in favor of someone else. Everyone knows this, and each interest group tries consequently hard to propagate *its* version regarding the general nature and the current state of social reality.

An *adequate* social theory must evidently comprise all of the various biased ('stream-lined') theories (socalled 'ideologies'), but no interest category can be expected to be really interested in such a theory that respects the arguments of all the adversaries equally much as one's own. (Lenin claims even that there is no such thing as a social theory that is not an ideology. (The exact Lenin quotation can be found in Klaus 1973, p 4.)) Fanatism is more desirable than truth in the struggle for power. Each deflection from the socialist ideology strengthens the bourgeois ideology, says Lenin, for instance. The Catholic church burned Giordano Bruno, forced Galilei to abjure, and still keeps an *index librorum prohibitorum*. Marx, Marxism, and Marxists were and still are suppressed in the socalled 'free world'. Et cetera.

We conceive of the relationship between an adequate multi-faceted social theory and ideologies as being analogous to the relationship between justice and jurisdiction. We know, at least since the Third Reich, that not all by law forbidden things are unethical, and not all legal things are just. (Cf. Strahl 1958.) 'Justice' is a fuzzy conception beyond concrete laws and legal institutions. An adequate social theory is likewise an indefinite goal beyond all ideologies.

But an adequate, 'pluralistically balanced' social theory must necessarily be utterly complex, too complex, in fact, for being of practical use for humans unless they are aided by a computer. The recent advent of the computer as an aid for dynamic modelling has augmented man's theorizing capabilities quite significantly, and thus also moved the complexity barrier on the road towards more adequate models of social reality into a farther distance (and closer to the indefinite goal).

1.2. What is Sociocybernetics?

Sociocybernetics, in the sense in which this name will be used by us, *is the discipline that is concerned with the problems regarding the cybernetic modelling of social reality.*

Sociocybernetics is not primarily concerned with empirical social research, but rather with the question of how to derive and use the results of empirical social research.

Sociocybernetics can be said to be an augmentation of sociology. It deals with the eternal problems of social philosophy, but it does so in cybernetic terms and with the aid of the computer.

Sociocybernetics is a specialization of general cybernetics; there is, for obvious reasons, extensive overlap with biocybernetics, which is another specialization of general cybernetics and which is concerned with living systems in general.

Sociocybernetics is an interdisciplinary field of study, by present day standards. We believe that general sociology, all special sociologies, anthropology, archeology and history, economics, social philosophy, ecology, medicine, psychology, psychiatry, and robotology are of direct relevance to sociocybernetics and/or can make use of sociocybernetic research methods.

(General) Cybernetics and General Systems Theory are nowadays often used as almost synonymous concepts. Both have also come to be able to evoke a multitude of different conceptions and associations in different readers. It is therefore still very much necessary to be quite explicit about one's conception of what cybernetics is all about and about the basic concepts of cybernetics one intends to use in one's text.

1.2.1. What Is Cybernetics?

'Κυβερνητική' was the ancient Greek term for the 'art of steering boats', but already Platon used the word in a less literal sense for denoting capability of political control. A.M. Ampère used the word "cybernetique" (1834) in this latter sense (Anschütz 1967, p 9).

In 1947 appeared the book entitled "Cybernetics or Control and Communication in the Animal and the Machine" by the mathematician Norbert Wiener. This book summarized a lot of new mathematical, technological, biological, and philosophical ideas which had appeared during the thirties, been developed but redtaped during the war, and which then simply were 'in the air' in the professional circles. The book's publication was ideally timed to be able to name a fast growing system of ideas and research results, among these the development of electronic computers.

But it was first W. Ross Ashby, a British biologist, who in his two books "Design For a Brain" (1952) and "An Introduction To Cybernetics" (1956) systematized and formulated more explicitly, precisely, and also in a more generally readable style the concepts and conceptions which Wiener had only indicated.

1.2.2. What Cybernetics Is Not

Although cybernetics has to a large extent been developed by mathematicians, although its central concepts have become embedded in mathematical calculi, and although cybernetics for this reason can catalyze the 'mathematization' of a non-formalized field of research, it is anyway incorrect to equate "cybernetics" with "formalization/computerization": a definition based on such a equation is too *wide*.

On the other hand has cybernetics often been equated with prominent parts of it, which has led to definitions which have been too *narrow*: Cybernetics is not only control theory, nor merely information theory or communication theory, nor just general systems theory, nor congruent with computer science.

1.2.3. Cybernetics As a Theory and As a Metatheory

Cybernetics has originally been an engineering science, a synthesis of a number of bodies of specialized technological knowledge. The abstract mathematical formulation of this knowledge implied simultaneously a generalization which enabled the originally separate and specialized theories to be linked into a single theory with many aspects. This general, formal theory was soon found to be open to many non-technical interpretations, in biology, medicine, sociology, psychology, f.i., and it has thus been used as a metatheory for these sciences.

1.2.4. Cybernetics versus Positivism and Behaviorism

Cybernetics is often claimed (e.g. by Anschütz 1967, p 18) to advocate a position similar to the ones held by positivists (such as Ernst Mach) and, regarding human systems and studies of their behavior, by behaviorists (following John B. Watson). The objective of Science, according to these conceptions (in their pure form), is merely to seek to detect relationships between obtained measures.

It is, of course, true that cybernetics also has this scientific goal, but only in cases of extreme informationlessness or for standard applications is the cybernetician satisfied with merely analytical relationships between measures. However, whenever the assumption of a specific internal system structure ('intervening variables') is seen to result in more effective input-

output translation predictability, he finds it quite adequate to keep and make use of this assumption. The resolution of a system into a structured set of subsystems will in some cases confront the cybernetician with a quite new and larger set of systems ('black boxes') to be characterized.

1.2.5. Two Types of Problems in Systems Research

As a matter of fact, we need to distinguish two types of problems in systems research, namely analysis problems and synthesis problems. We have an *analysis problem* at our hands if we are to describe and measure the behavior (and more rarely also the morphology) of an existing system. We are confronted with a *synthesis problem* if we have a system description in our hands and are to build a model of the prototype; the model is usually to have identical or similar behavior characteristics as compared with the prototype system; more seldom is also morphological similarity a given design requirement, but it may be a consequence.

Sociocybernetical modelling involves simultaneously both types of problems: The detection of behavior invariances in the empirical prototype is the analytical half of the modelling problem; to construct a system which manifests similar invariances is its synthetical half.

1.3. Our Intentions

Homo Cyberneticus is an attempt to specify a sociocybernetic basis for modelling social reality 'pluralistically'.

We try to computer-simulate the behavior of artificially intelligent 'social robots', which, as side-effects of their cognitive information-processing (or belief-system handling), generate 'emotions' and 'attitudes', and which, in their total behavior, are not only cognitively constrained and motivated, but also by their embodiment states.

These 'social robots' are assumed to exist (and to interact with each other) in physical and cultural milieus that are similar to those with which we are familiar through own experience, through sociological and anthropological literature, or through fiction.

1.4. Our methodology in general

Our simulation program is written in LISP, for maximal flexibility. LISP is a list-processing language, commonly used in artificial intelligence research. (Cf. Mc Carthy et. al. 1962; Weissman 1967.) Very recently we have started to use REC (cf. Volume 3).

The total program (or '*simulation system*') comprises two subprograms ('subsystems'): A definition of a *monitor* which is to assist us during the specification, modification, and execution phases of a simulation, and a definition of the *model* of a society comprising 'social robots', including, in particular, the specification of behavior rules for these 'social robots'.

The simulation model is '*modular*' and '*incremental*'. The former means that the model parts can easily be replaced, for instance by improved versions; the latter means that the whole model needs not be complete when we begin to run it and that it can be augmented indefinitely while we run it.

The simulation model is '*multi-levelled*'. This means in our case that we not only simulate interactions between 'social robots' (we call them 'persons'), but also between persons and aggregates of persons (such as groups or organizations), and/or between aggregates and aggregates.

Such multi-levelled simulation is to be performed in parallel.

The simulation model is to be largely '*self-organizing*'. The 'backbone', so to speak, of our model is a general life-trajectory scheme. As new persons are 'born' into the model, they are socialized in a very differentiated manner. In the course of social interplay they acquire acquaintances (first parents, then peers, collegues, etc.), experiences, beliefs, interests, attitudes, habits, commitments, merits, social images, perhaps a criminal record, a wife and kids, a self-image and an ulcer. Few of these acquisitions happen quite at random, most are instead constrained and/or motivated by past acquisitions and the person's present natural and/or socio-economic environment.

Thus, in principle, all we need to start with is an Adam and an Eve in order to generate a family which can generate a next generation, etc. If the environment is variable and the personality-accumulating functions not very crude, we need not fear to obtain exact Adam-and-Eve replica generation after generation. Besides, the researcher can easily participate in the simulation now and then and influence the development.

Eventually, we have obtained a very detailed and balanced social network, and all persons have developed individual personalities. The depicted social system may have any size one can store in the computer.

1.5. On Data and Model Validations

Simulation models need to be *valuated* (that is: all variables need to be given concrete values) and *validated* (that is: the model designer is to 'prove' that his model is 'adequate'). Empirical data are usually used for both purposes (two different samples, of course, if we are to avoid regression fallacies).

Initially, we shall predominantly use introspective and secondary data for valuations; these can be replaced later on when we have experimented sufficiently with the methodology as such.

As to model validation, we expect our model to be of very high 'face validity'. Therefore, we can ignore the initial model's empirical validation. Only when the model is empirically *valuated*, we need to try to *validate* it empirically, too.

1.6. The Atman Project

Homo Cyberneticus is the report on a research project, called Atman Project, which has been financed by the Swedish Riksbank Tercentenary Fund since 1968, and which has had as its goal the implementation of a causal simulation model of everyday life. The project staff comprises four persons: *Lennart Stålberg*, who predominantly has taken care of the project's sociological literature research, but who during the last year also has taken part in the very modelling (cf. volume 5); he has been with the project since 1970; *Tore Risch*, who with great skill has transformed raw program versions into bug-free and efficient programs; Tore joined the project in 1972, succeding *René Reboh*; and *Hans Jürgen Holstein*, who has been the project's initiator and its 'motor'. *Torgny Tholerus* has been a project member since early in 1973; he has invented a successor language of LISP (called REC) which promises to be faster and more concise than LISP, and very adequate for our type of modelling (cf. Volume 3).

The Atman project collaborates with the Computer Science Laboratory at Uppsala, and has had moral support from a few people at the Department of Sociology at the University of Uppsala, most tangibly from Professor *Birger Lindskog*.

1.7. An Ethical Dilemma

Social science can, on the one hand, guide the improvement of social conditions, but it can also be misused for the exploitative purposes of totalitarian states or of firms. The access to planning models, data, and computers are nowadays an obvious power factor.

Social scientists are thus Janus faced. There is a danger that we all argue like an Eichmann: "If I don't do it, somebody else will, and my sacrifice is worth nothing." Is it therefore reasonable to forbid social science and to renounce thus its potential of positive effects?

We are not sure. We feel at present that it would be more wrong to remain quiet and not to object against technocratic planning that distorts our societies with operation analyses, linear optimations (that more often than not are suboptimations), econometric flow simulation models, rationalization projects, and implementations of semiautomatic chicken-farm designs called satellite cities.

Although technological innovations can help to resolve the antagonism between man and Nature, they must not simultaneously sharpen the other antagonism, namely that between man and society. Power misuse seems to us to be more probable in a rationalized but disrupted society than in a slightly less rational but still coherent one. That is why we feel that research regarding more 'holistic' planning models, in which man also can receive a more adequate representation, is justified after all. Because the adequacy of the planning models determines to an essential extent the adequacy of political actions, and thus also the adequacy of present and future physical and social milieus we are to live in.

2. The Simulation Monitor

Homo Cyberneticus is a *way of modelling man*, namely dynamically, causally, heuristicly, and morphogenicly. That we must use a computer for modelling is merely a consequence of the complexity in the models we thus obtain. "Modelling man" means therefore predominantly "computer simulation modelling of man".

Computer simulations require two things: a simulation *monitor* and a simulation *model*. The monitor is in our case an abstract model of how the world is structured and how it behaves, while the simulation model consists of a set of rules (called *jigs*) which give the abstract monitoring model a more concrete content.

Within our monitor we can distinguish two major mechanisms: *the Top Loop*, which is a very abstract world model, and the *Jig Processor*, which is an abstract model of human behavior. (The Jig Processor can also be used for modelling the behavior of social aggregates in an anthropomorphic manner.)

2.1. The Top Loop

The Top Loop is a circular sequence of monitor functions which trigger 'packages' of simulating functions. It includes also a 'package' of functions which handle the intricate updating of time.

The Top Loop is extremely simple:

(.1) Trigger the 'step-up-time package',
(.2) Trigger all time-dependent monitoring and simulating functions. (for instance, trigger a 'package' of demographical, macro economical, and macro-political trend simulations),
(.3) Focus upon one randomly selected individual ('Self'),
(.4) Determine Self's present physical and social context,
(.5) Simulate Self's basic biological and psychological processes,
(.6) Simulate Self's social behavior,
(.7) Go to (.1) and continue there.

(Note: We do not yet expect our readers to understand the meaning of the top-loop steps; we wish merely to convey a first vague idea of how the whole system works. The rationale and the effects of the individual steps will be explicated in the rest of the text.)

2.2. The Jig Processor

The Jig Processor is composed of a set of functions which control the evaluation order of a set of other functions which we shall call *jigs*. Jigs, according to our specific definition, are functions which are meant to simulate stereotypes of social, psychological, and biological behavior.

The Jig Processor is described in detail in section 7.

2.3. The Jig Methodology

The reader will note, as he continues to read this booklet, that we rely heavily upon specifications of *stereotypes*. Usually, we first try to find crude schemata for describing the phenomena we study, then to find more refined subschemata for each of the crude schemata; etc. The reader will find that we have used this approach for delimiting the variability in spatial and time patterns (i.e., in 'contexts' and in 'curricula'), and in behavior-dependence upon personality-characteristics (which we try to catch in 'task jigs', 'action jigs', 'goal jigs' or 'perception jigs').

As a matter of fact, science is not primarily concerned with particular events but with invariances in structures and processes. Our 'jig methodology' reflects this basic epistemological objective.

3. The Morphology

Our simulations start with the definition of a *morphology*. A morphology, in the specific terminology which we shall use here in order to be able to communicate concisely and unambigously, is a hierarchy of *contexts*. A context (or synonymously: a *setting* or a *milieu*), in turn, is a more or less distinct collection of material objects and/or persons, usually (but not necessarily) located within a particular geographical region; each context is, in principle, associated with a set of norms for behavior within that context. Examples of contexts, in this very specific sense, are a family, a bus, a suburb, a park, a dance party, a lecture, a debate, a neighborhood, a clan, a baseball game, a person reading a book, two persons talking with one another on the phone.

When we look at a list of examples of contexts we see that some can be understood to be *subcontexts* of other contexts: f.i., a park can be part of a suburb, a person reading a book can sit in a bus driving through a village. The same context can be subcontext of several other contexts: a family, for instance, can be part of a clan and of a neighborhood and of a garden party simultaneously.

If A is a subcontext of B, then B is said to be a *supracontext* of A.

We said above that a morphology is a hierarchy of contexts; this was obviously an imprecise explication, because we have now seen that the hierarchy is *not strict*, that is: a morphology is not an algebraic ordering called a tree, although it in exceptional cases may be one; the official ('formal') structure of organizations has often tree form, for instance.

Christopher Alexander (in Bell/Tyrwhitt 1972, p 401–428) argues that cities are not trees but *semi-lattices*. A semi-lattice is defined to be a set of sets such that whenever two sets overlap, then we can find the union of these two sets also to be included in the semi-lattice. We cannot, however, generalize this postulate to be valid for morphologies in general; we find it to be too strong. A single example can justify the rejection of a postulate, expecially if its adoption does not simplify but rather overburden practical work. Our test example is the following: Assume that a clan and a neighborhood are overlapping contexts; what then is, in empiry, the context which corresponds to the union (and *nothing but* the union) of the two?

We do, in practice, not wish to be forced to explicitly specify all contexts

which theoretically could be derived from two or more other contexts with the help of ordinary set-theoretical operations on sets or of more specialized operations definable on contexts. But it is practical to be able to specify a weak ordering among contexts in order to be able to spell out the constraints which we know to exist for instance, that a suburb never can be the subcontext of a family, nor a family directly the subcontext of a metropolis, etc.

3.1. Morphology Generation by Rules

A social system's morphology is at least two dimensional: we shall as yet distinguish *physical contexts* from *social contexts*. Physical contexts can have only physical subcontexts and social contexts can have only social subcontexts. But physical and social contexts *coincide* with particular probabilities.

The morphology is defined with the help of morphology-generation rules. For instance, if one such rule is (★Each park resolves into 1 car park, 1-2 greens and 0-2 sport-fields), then, whenever we during the morphology generating phase of our simulation say that a given context is a park, we wish the computer to randomly specify this context further according to the supplied rule.

Thus, if we have specified the rules

(★Each farm resolves into 1 family,
1-2 person with-status farmhand,
1-2 person with-status maid)
(★Each family resolves into 1 person with-status father,
1 person with-status mother,
1-3 person with-status son,
1-3 person with-status daughter)

and wish to create 7 farms, we need merely write (★Create 7 farm) and the system will create 7 randomly different farms according to the given rules.

Of course, if we specified a morphology quite explicitly, no 'resolution rules' would be necessary. But if we wish to simulate a large social system (without having in mind to model *one* particular empirical system, but rather a *type* of system), the explicit specification of the system's morphology would require extensive and unnecessary efforts. (The computer is, after all, meant to *relieve* us of this kind of efforts, not to *demand* them from us.)

Not all subcontexts of a context are equally frequent. In order to be able to control the automatic 'resolutions' better, we need to supply numbers

which delimit frequency ranges. For instance, a metropolitan area could be 'resolved' as follows:

(★Each metropolitan-area resolves into 1 city,
3—10 suburbs and
1—5 industrial-area)

This rule says that a metropolitan area always comprises exactly one city area, at least 3 and at most 10 suburbs, and between 1 and 5 industrial areas.

However, this control is still not sufficient. We need also be able to enable biased sampling of one alternative from a list of subcontexts.

We write "(Probability P1:S1 P2:S2 P3:S3)", if we wish that S1 is to be chosen with the probability p1, S2 with the probability p2, S3 with the probability p3. For instance,

(★Each institution resolves into
(Probability 10: 1 library
30: 1—3 classroom
50: 1 cultural-institute
10: 1 political-institute)

means that in 10 % of all cases shall an institution be specified to be a library, in 30 % of all cases to be classrooms, in 50 % of all cases to be a cultural institute of some kind, and in the remaining 10 % of all cases to be a political institute.

Or, to give an example of slightly more detailed control:

(★Each school which-is (small, rural) resolves into
(Probability 10: 4 classroom and 2—4 person with-status teacher
30: 3 classroom and 1—3 person with-status teacher
30: 2 classroom and 1—2 person with-status teacher
20: 1 classroom and 1 person with-status teacher)
and 0—1 person with-status janitor).

3.2. Social Contexts

Usually, but not always, will Self (cf. Section 2.1) be in at least one social context (besides being in a physical context, of course). The social context, in turn, can be embedded in any number of other social contexts, precisely as a physical context can be embedded in any number of other physical contexts.

Certain social contexts can be made to always overlap with specific physical contexts. For instance, a group of collegues who never meet outside their office. Other social contexts can be associated with lists which in-

dicate probabilities for overlap with certain physical contexts; for instance, a football team which usually can be found on a certain ball field, less often in a certain locker room, sometimes in a certain club-house's restaurant, occasionally in other ball fields, locker rooms, or restaurants, or in a certain bus.

Similarly, we can indicate logical or factual overlaps between social contexts. For example, an informal organization aspect will be assumed to co-occur (by definition) with a formal one. More extraordinary and temporary social contexts, such as a cocktail-party-type context, or a talk-over-a-drink-type context, or a cup-of-tea-type, or an elevator-type, or a conference-type context, must be explicitly added to the intitial morphology as they are generated in the course of social processes.

We need to specify context-overlaps explicitly. Context overlaps are never partial.

3.3. Cxsorts

Contexts must be distinguishable as being of different sorts, which we shall call *cxsorts*. Household12, for instance, will be of the cxsort 'household', while 'person12' is of the cxsort 'person'. If we chose to have less prosaic names than "household12" and "person12", for example, "the Cathcart's" and "Charlotte Rhodes", it would be more evident that we need to specify the cxsort of each particular context. Only when we generate a morphology with the help of 'resolution rules' will particular names and cxsort-names have such a simple correspondence as "person12" has with "person"; that is because the particular names are derived from the cxsort-name by merely updating a number. Whenever we instead introduce new contexts when using explicit morphology-modifying or generating statements, there is no hinder to use names such as "Pee Wee" or "Harry Revel" instead of numbered ones.

Being given a standard morphology, we can, of course, still easily make explicit modifications at any point and of any kind, in order to make it depict the sort of social system we have in mind to simulate.

3.4. Agents

The terminal elements of a morphology are not contexts but *agents*; in our provisional morphology we let persons be the only agents, but we could also have chosen to simulate at a higher level of abstraction and let

primgroups, households, workgroups, cliques, and groups of friends be the agents.

We intend to eventually introduce a feature into our system which makes it possible to refer to specific subsets of agents (such as women, children, dept heads, supervisors, married housewives with children under school age; all of these are persons, but with particular properties).

Each exsort of agents needs to be provided with *generic behavior rules* (that is: rules which are valid for *all* agents of the corresponding exsort; for instance, for all persons, or for all households). We must also supply values for all of the variables which are mentioned in any of the applicable behavior rules for a given agent. Each individual agent is to be characterized by an individual set of values. These values are usually chosen at random when the agent is created, possibly with variable specific biases to reflect skewness in empirically observed distributions. The set of all such values of a given individual agent is said to be the agent's *property list*.

3.5. Basic Contexts

Basic contexts are such social and physical contexts which have no subcontexts, but which contain agents. For instance, if families are said to consist of persons, and persons are assumed to be agents, then we can conclude that families are basic contexts, basic social contexts in this case. The basic-context concept will unfortunately have a continuously shifting denotation when we assume that agents can turn into contexts during whatever period of simulation we currently have in mind, and vice versa. Such 'metamorphoses' will be desirable if we wish to alter the simulation's level of detail. Also, the destruction of some basic context will turn the vanished context's supracontexts into basic ones. (This shall be explicated in the next section.)

3.6. Movements of Agents Within and Between Contexts

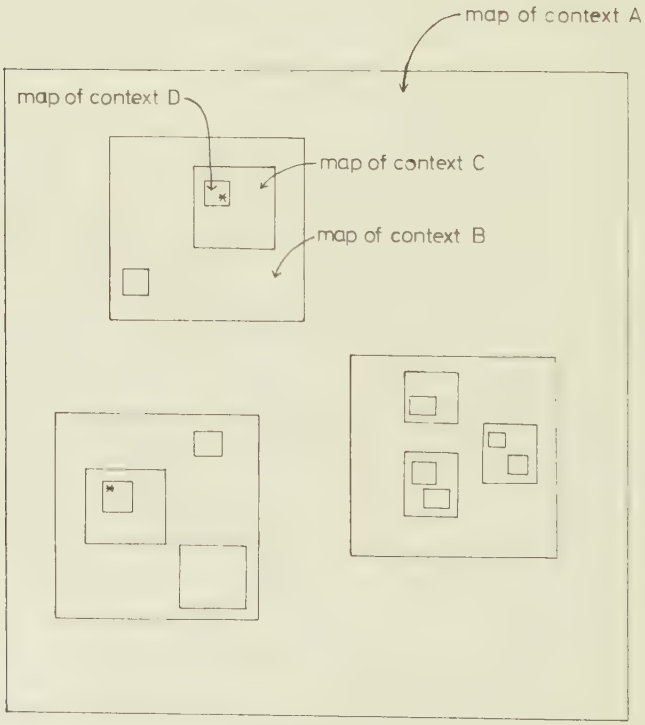
Each physical context is associated with a *map*. A map is a two-dimensional array of elements called *cells* or *locations*. These cells can, in turn, be associated with lists. One such list is a list of the names of those subcontexts and/or agents which are *located* at this cell; this list is called the *list-of-contents* of the cell. Another list of names can be used to

differentiate between different sorts of cells, for instance, between dry land and water, or to mark out a road or a river or a border; this list is called the *list-of-sorts* of the cell.

We do, as yet, not attempt to make the maps of different physical contexts fit in such a way that when an agent moves over the boundary of one, he automatically enters another. We assume instead that the contexts are relatively closed and that an agent needs to explicitely *decide* to leave a context and possibly to enter another.

Social contexts do not have maps, but they are also regarded as relatively closed.

Every context is contained in the map of its supracontext. Every agent is located somewhere in the map of the physical context which he presently belongs to. This can be illustrated as follows:



Context D is evidently a subcontext of C, which is a subcontext of B, which is a subcontext of A. The asterisk in the map of D denotes that an agent is located there. If that agent should explicitly leave the context D without explicitly joining another, he shall *occupy* (that is: be content of) the same cell as context D does in the map of C. The same argumentation is to be the rule when D was a temporary context and has ceased to exist.

Movement of an agent within a basic physical context leads to the removal from the list of contents of the former location and the addition to the list of contents of the new one. Movements of an agent from one context to another is furthermore reflected in the explicit *member list* of the two involved contexts. A *member* of a context is any subcontext or agent located somewhere in the context's map.

3.7. Temporary Contexts and New Contexts

New social contexts, more rarely new physical ones, can be created in the course of social interaction. When two people meet and decide to create a home of their own, they create at least a new social context, namely a family, but perhaps also a new physical context, namely if they have a house built for them. If they separate before they have had offspring, the family disintegrates again; it has thus been a temporary context. If they have had offspring we may say that the family is *replaced* by new contexts; by *one* if one parent takes care of all children; by *two* if each parent takes care of at least one child.

Contexts can be much more ephemeral: It may be a collection of strangers who happen to share an elevator, or two former collegues who meet accidentally and decide to take a short drink together for old time sake, or two people talking with one another on the telephone.

New contexts enter the morphology as subcontexts of the context within which they were created. The involved agents are made to leave the supracontext whenever they enter a subcontext.

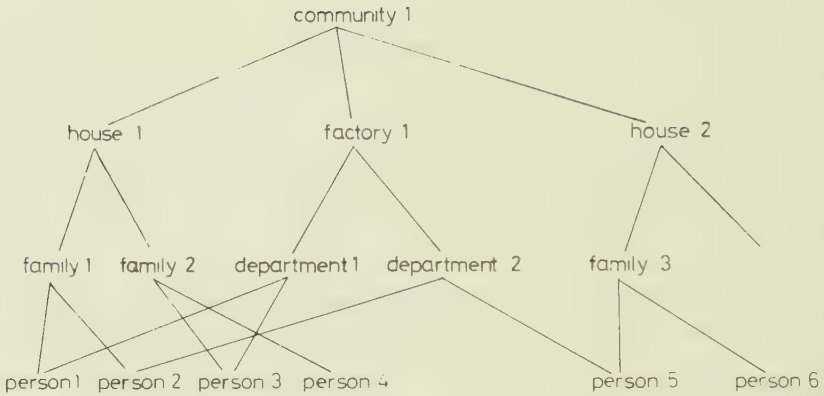
4. The Social Interaction Structure

When the model's agents are defined, we can procede to define a *social interaction structure*. (Unlike the socio-economical status structure is this social-interaction structure neither purely theoretical nor hierarchical nor computationally derivable from the property lists of all agents.) This social-interaction structure can initially be imposed quite at random. Because if the agent's behavior rules are adequately defined, empirically in frequent interactions will also soon be infrequent in the model, while fre quently found links will also become frequent in the model once the simula tion has started to run.

Now who interacts with whom? That is a crucial problem, but on the surface it is not very difficult to model. We know that persons tend to (A) interact most often with other persons whom they have interacted with often before;
(B) prefer to perform rewarding actions to unrewarding ones, and will not act if they expect predominantly negative consequences; thus, persons try to interact with people whom they believe to be willing and/or able to reward them; also: persons will interact with other persons if the very in teraction is conceived of as rewarding (or at least partially rewarding).

Regarding first-time interactions we can safely assume that if A and B interact in context C with frequency F1, and A and D interact in C with frequency F2, then B and D will be '*introduced*' to each other by A in C with a probability which is directly proportional to $\sqrt{f1 \cdot f2}$.

If we assume interactions to be context bound in the manner indicated in this last sentence, we need also specify with which probabilities or under which circumstances agents will enter into new contexts. For instance, with what probability and/or under which circumstances will a worker's wife meet her husband's collegues? Obviously, it must be made more probable for a person B in context C to meet a person D in context E via person A who belongs to both contexts rather than if C and E are immediate sub contexts of different contexts only. For instance, given the morphology



We wish the model to let persons 2 and 5 have greater probabilities of interaction than 3 and 5, and 3 and 5 greater probabilities than 4 and 5. By the way, persons 1 and 2 may have met at the factory for the first time. We must therefore try to find a set of rules which reflects our wishes. We see that persons may choose to create a new common immediate supracontext (for instance: family1 is a common immediate supracontext for persons 1 and 2) in order to be able to interact more directly. New contacts can then be made via such new contexts, of course. For instance, if the collegues person2 and person5 should become friends, person2 and person6 would probably meet if this group of friends often chose to meet at house2.

We must obviously bias the sampling of interaction partners in such a way that agents who simultaneously are located in the same social *and* the same geographical contexts have the highest probabilities to interact (and these probabilities are automatically higher when these contexts are smaller); agents who simultaneously are located in the same geographical context only, or the same social context only, are to have significantly lower chances to interact, especially if these contexts are large.

We propose the following sampling procedure:

Step 1: Sample 1 agent from the list of all agents;

Step 2: Sample 1 context from the list of the selected agent's all immediate supracontexts; and

Step 3: Sample 1 agent (= the interaction partner) from the context obtained in step 2.

This procedure must only guarantee that each person is equally probably chosen to be the *first* agent ('Self'); the probabilities of the *second* agent's being chosen are to be conditional, mainly conditional upon Self's probability of being in the context chosen in step 2, and upon Self's relative degrees of compatibility and acquaintance with the other agents in that context. That means: sampling in step 2 needs to be weighed by probabilities of being in a context, and in step 3 by the relative degrees of acquaintance and compatibility (or trust).

Of course, if we wish to focus upon some specific non elementary context, we may very well restrict our sampling in such a manner that Self is to be drawn from the list of all agents presently located in that context or in any of its subcontexts.

As a special rule, in order to enable chance encounters, we may require further that no agent has zero probability of being chosen as an interaction partner for some other agent in the same context. Interaction, naturally, must have an acquaintance-degree raising side-effect which is recorded in order to be usable in later samplings. The degrees of compatibility (which approximately indicate degrees of trust and/or of potential 'liking' and of potential 'utility') can be computed directly on property lists. (Potential 'liking' and potential 'utility' become 'liking' and 'utility' when the degree of acquaintance is given.) High compatibility favors interaction, interaction generates acquaintances, and acquaintance makes aware of incompatibilities and of compatibilities. (The measure of compatibility is therefore to be a measure of *net* compatibility; it is assumed to be zero in the case of complete ignorance.)

It is not yet important exactly how we define the computation of the compatibility measure. We need only specify that it ought (at least vaguely) reflect similarity of socio-economic status, background similarity, goal similarity, and amount of cooperation.

With these rules and a morphology given, we can now simulate the growth and modifications of acquaintance networks (the social interaction structure) which include average adult persons and non personal agents. The inclusion of a birth routine, which creates new persons, requires additional assumptions regarding the interaction-partner choice biases; we must try to account also for the deviant behavior of 'shy' people. We shall therefore assume that whenever an agent is a person, acquaintance and compatibility are not the only weights used in step 3 above, but that there is at least one other factor, namely the person's degree of self-confidence. The higher the degree of self-confidence, the less weight is put upon earlier acquaintance. This self-confidence value is assumed to be context-specific, but we define also a *general* self-confidence level (which we call *confidence*

tonus) which is the average of the context specific ones, each of these being weighed by the amount of time spent by the person in that context. The *specific* self confidence value is computed as the average of measures of 'rapport' during interactions in this specific context. These 'rapport' measures are measures of immediate reactions upon the interaction partner's behavior. (Our hypothesis is here that self-confidence is not predominantly 'rationally' but rather emotionally formed.) When one enters a specific context for the first time, the self confidence value is assumed to be the average of the specific self confidence values for all contexts of the same type. If the context is of a type never encountered before, the default self confidence value is taken to be equal to the confidence tonus.

The first specific context into which new-born babies enter is the mother baby dyad. The baby is passive with regard to interaction partner selection: it has no acquaintances at first, no compatibility measure. But very soon the baby has a high specific self-confidence and exactly one acquaintance within this dyad.

5. A General Life-Trajectory Scheme

We do not wish to ignore the fact that people have expectations on their lives and that they act in accordance with them: that they have goals in life, that they develop chances, opportunities, backgrounds, careers, and obligations; that there are different phases in human development and life, such as a child period, adolescence, education, mate selection, the family cycle, the middle-aged period, retirement and old age, each creating specific problems for a person; in short: that life is not a mere sequence of random actions and interactions, but that it rather should be viewed as a plurality of more or less uniformly ordered parallel (and sometimes crossing) sequences of constrained actions and interactions.

The everyday life of a person, upon which we shall focus closely in the next chapter, is embedded in long-term processes, some of which are biological, some physiological, some social and cultural, some economical and political. Some are very personal processes, such as the process of age ing; some are impersonal processes, for instance changes in public opinion.

Charlotte Bühler, in the introduction to one of her books on life expec tations and life histories (Bühler 1972, p 5), points out that certain problems are common to all people: before all others naturally the problem of having only one life time at one's disposal. All people have expectations and hopes: some have greater, some smaller; some happen to be more for tunate than others; some are more satisfied with their lives than others; but no one knows how the rest of his life will come to be, nor how long he will live.

We do not know in which ways people would live differently if they knew that they could happen to live for thousands of years instead of tens. But we are convinced that a person's realization and consequent awareness of the fact that first his/her youth is short, and then that life as a whole is short, puts him or her under a certain stress (which, it seems, varies from person to person in intensity), which affects his or her choices of behavior alternatives. We believe it to be plausible that people with this kind of awareness tend (in proportion to the awareness intensity) to try to make use of favorable opportunities as they happen to occur, while unaware per sons would more often not be motivated to become active. "Look around the world while you are young and free" is a slogan which well exemplifies the kind of reasoning we believe to lie behind a good deal of more extraor dinary activities.

Especially political activites seem to us be very much affected by lifespan and way-of life perspectives, which *may* be the reason why it is not easy to get people to voluntarily 'sacrifice' their lives (in a war or in a totalitarian societal system) for the sake of a better future a decade or half a century from now. Also the 'revolutionary spirit' of young people may be not only a consequence of their not yet being caught in nets of obligations but also of their awareness that they must have defined a way-of-life for themselves by the end of their adolescence: where their more or less basic ambitions clash with reality's constraints they seek possibilities to remove, or at least modify, these constraints. (After they have been 'broken in' by society in one way or another, they will, of course, still have ambitions as to their ways-of-life, but such ambitions tend to concern less crucial features: to be 'broken in' means simply to have learned that one's own capacities to influence reality are utterly limited and that many other people more or less inadvertently or involuntarily see to it that it stays that way.)

By the way, Charlotte Bühler also points to the fact that there is only very unsystematic education regarding the ability to time and master one's life as a whole. It would be extraordinary pleasant if our simulation system could become a tool for such education. Books, teachers, psychological texts, and vocational advisers are rather evidently not sufficient as sources of information on the chances of a particular person with particular interests, goals, abilities, and personality traits, to realize some way-of-life in a given society.

5.1. The Abstract Life Trajectory

The *life-trajectory* of a person ('Self') is the complete record of Self's behavior during his life-time. At the beginning of a personal life-trajectory, that is: when a sperm merges into an egg, we find an individual without personal experience of the environment to be coped with, and yet: the individual is not without behavior determinants.

To regard a fertilized human egg as something else than merely a physical process, for instance as a chemical, or as a biological system, is, of course, an *abstraction* implying a structuration. Also to study people from psychological and sociological points of view is to focus attention upon certain types of invariances in a purposeless physical process. This is, as you know, not our introspective 'knowledge' of what we are ourselves; we notice instead that we have self conceptions, goals, emotions, a will, a conscience, etc. We need return to this discrepancy later in this chapter.

The behavior determinants that we mean to exist from the start of an individual life are by us humans conceived of as chemical and cell-biological rules, among them the very essential rules for decoding genetic information. On whatever level of abstraction we choose to discuss these first moments of what we conceive of as the individual life of an organism, a process distinct from the processes around it, we must not miss to notice that each component of this very organism *reacts* to its environment. Reactions, as state-selection processes, require (according to our causal

world views), selection criteria (or other words: reaction determinants) within the reacting organism (or mechanism). Such reaction determinants can, of course, be the very physical properties of the organism (or mechanism), for instance, an osmotic pressure, or a degree of elasticity of some component.

The organism reacts, and this reaction affects its future: in part immediately, because the organism changes some of its properties, some later because the organism, with its changed properties, may affect its environment differently, and because it also may come to react differently to its environment after these changes. We can invariably find, whenever we study reactions, that the reacting system either 'tries to' *adapt* (which means that it changes some of its properties, which *may* lead to modified suceptibility to environmental influences of a certain kind) and/or to *attack* (or counter-influence, which means that the reacting system changes its properties in such a way that it *may* happen to affect its environment in a manner which makes the environment adapt and possibly change into a more 'compatible' one) and/or to *flee* (or to isolate itself; which means that the reacting system does not 'try to' modify but to replace its immediate environment). Of course, adaptation, attack, and flight are merely dimensions of a human (anthropomorphical) interpretation of reactions, they are not 'intentions', in a psychological sense, in non human processes, nor in all involved in a human organism.

The organism, with each reaction, thus modifies the conditions for its next stimuli and reactions, from the first moment of its individual life to the last (which, by the way, is much more difficult to define than the first). Its repertoire of reaction possibilities is, at each moment of its life, determined by its past. This does not imply that it also can be completely predictable by any observer, however.

Our conception of an abstract life-trajectory is based upon the invariances we can find in the reactive behavior of organisms, or of automata in general, over time. An abstract life trajectory is simply the potentiality of behavior of an automaton with inputs and memory before we have specified any initial values.

There is only one abstract life trajectory: we define it as being generated by the process

$$X(t) \times S(t) \rightarrow S(t + 1) \times Y(t + 1).$$

(The formula says merely that a system's next state and its next output depend upon its present state and its present input. (Cf. Volume 2.))

The significance of the notion of an abstract life trajectory lies in the very possibility of its mathematical symbolization. It has no other task for us.

5.1. Our Notion of a General Life Trajectory

We believe it to be possible to explicitly state invariances in the factual life trajectories of all human beings beyond the basic invariances expressed in the abstract life-trajectory formula. But we shall not bother to do so, because we have practical purposes in mind when we pursue philosophical enquires.

We shall instead try to elaborate a *general life trajectory*, a scheme based upon invariances observable in the factual life trajectories of human members of a given society. Values, decisions, goals, biases etc. will in this effort only be regarded if they transcend everyday life, that is: if they con cern and influence long-term processes. Of course, we ought eventually state explicitly and precisely what we choose to call a long-term process in constrast to a short-term, everyday-life process. But as yet, we can only make a 'fuzzy' distinction: we predominantly regard frequently observed decisions which are seen to usually influence a person's way-of-life for several years or for the rest of his life, such as the choice of education level, of an employment, or the decision to marry. We also take into account such biological processes as puberty, the climacterium, and ageing in general; or events such as the birth of children or the death of a life compa nion; or social institutions such as obligatory military service. What is typical for these life-trajectory determinants is that they usually cannot or will not occur at just any time in life (as an illness, or an accident, or the death of an aunt could).

5.3. Outline of a General Life Trajectory

(.1) Pick out an appropriate pair of persons (sexually potent, and at present not practicing birth control, in geographical and functional proximity, usually socially and culturally compatible, of opposite sexes, usually of approximately the same age, and usually directly acquainted (or with common acquaintances)) and let them be the parents of the new-born child.

(The child is, of course, directly associated with variables such as age, and sex, and with hereditary traits.)

(.2) The child interacts first with its mother, later also with its father, and learns to recognize them. It thus lays the ground for its own network of acquaintances.

The amount, and the type, of stimulation during this and the following life phases determine the child's rate of biological, psychological

and social development during these phases.

(.3) The child now meets the children of neighbors, of relatives, and of friends of its parents. It interacts with them, influences them and or is influenced by them, chooses friends among them. During its social interactions the child accumulates and eventually updates beliefs, values, attitudes, habits, social norms, and experiences. The child is given a relative status among its peers.

(.4) The child starts to go to the obligatory public school (possibly to a pre-school kindergarten first). The child starts to accumulate a list of *formal merits*. The amount of chance meetings increases.

(.5) Puberty occurs. The child becomes an adolescent and adopts the norms of a new subculture. Parental influence tends to decrease essentially, while the adolescent is eager to explore new social and physical contexts. The amount of chance meetings increases further.

At approximately the same rate as the adolescent breaks out of his social and psychological 'embedment' in his family-of-origin, he seeks to become 'embedded' in another stable social context: a group of friends, or a heterosexual relationship.

(.6) The adolescent either chooses to continue with his education, or to begin to earn money. In this decision he is influenced by his parents as long as he is economically dependent of them: If they want him to earn money, he has little possibilities to revolt; but if they want him to stay at school, while he does not wish to do so, it is more easy for him to force them to adapt, especially once he has come of age.

The parents, as well as the adolescent, are, also in this matter, influenced by the expectations and habits of their respective reference groups. But they may have to, or choose to, modify their ambitions as they observe the adolescent's difficulties or achievements in school. The adolescent's intention to continue in school is influenced by his relative achievement in his class, by his interests, and by his awareness of the long-term instrumental value of more extensive education.

(.7) The young person does not *need* to seek an employment the better off his parents happen to be, the younger he is, and the fewer his responsibilities (such as, for instance, towards a wife and children).

In trying to find a satisfactory employment, the young person has to bargain with different employers. (These employers can be modelled as task groups with different given tasks, trying to enhance their capabilities as profitably as possible, seen in the short and in the long run, by recruiting suitable cooperators. Different employers, however, differ in attractiveness, in pay level, public image, or work variety.)

(.8) With great probabiltiy, the young person will marry and eventually have children. As of today, it is empirically frequent that the female then plays the role of housewife at least until the children have reached adolescence, while the male partner simply continues to be an employee.

(.9) At a certain age, the employee retires and must again adopt a new way of life with practically unlimited amounts of leisure.

(.10) Eventually, the person dies.

6. Everyday-Routine Curricula

General Life-Trajectories are meant to serve as a crude and 'fuzzy' mesh or scheme which helps us to order life phases. Each life phase, in turn, needs to be structured with the help of a finer scheme, one that considers yearly, monthly, weekly, and daily routines. We shall therefore introduce the notion of *everyday-routine curricula* ('curricula' for short) which can be (automatically) ascribed to persons on the basis of certain person attributes such as sex, age, profession, marital status, and number and ages of children.

These curricula prescribe in a not quite compulsive manner, of course, how a certain *type* of person can be expected to spend his or her day, and which weekly, monthly, or yearly events can be expected. The curricula are thus obviously again time-steered, but we must naturally also allow for event-triggered behavior which disrupts the curriculum at least temporarily, for instance, an accident, or taking an afternoon off for an extraordinary activity such as buying a car or visiting the family doctor.

Curricula are the subjective correspondents to *time budgets* in empirical sociology (f.i., Szalai 1972, Sorokin 1939, Johansson 1964, De Grazia 1962, Andersen 1960). Curricula can be said to be occurrence and transition rules; they may be probabilistic or deterministic. Time budgets are statistics of occurrences and transitions which, in principle, can be computed on any number of distinct subpopulations of a total population. We could therefore expect this part of our simulation model's valuation to be relatively unproblematic. But time-budget studies have, in practice, as yet been too undifferentiated for our purposes, which forces us, for the time being, to invent curricula.

7. Individual problem-solving

We have now defined a morphology, a social interaction structure generator, a general life-trajectory scheme, and a set of standard curricula. With these components we can simulate the *frame* for everyday-life processes. But there is, as yet, too little individuality in the behavior of our simulated persons.

Individuality of behavior must not be interpreted and modelled as 'random deviations from average behavior'. Such an easy way out leads to no new insights about human behavior. Instead, we shall interpret "individuality of behavior" thus: Each simulated person ('Self') is during his life time confronted with a unique sequence of situations, which pose a probably unique sequence of problems to him. Self's behavior is understood to be predominantly problem-solving behavior, and as he tries to cope with his individual sequence of problems, he generates an individual sequence of actions.

Our next part model to develop ought therefore to be a 'General Problem Solver'. But let us first investigate whether this task is at all feasible at present.

7.1. Simulation versus Question-Answering

There exist two classes of approaches to problem-solving by computer; there are no established names for these classes, but we shall call them 'the class of symbolic approaches' and 'the class of simulation approaches'. (Let McCarthy's 'Advice Taker' (1959) be a representative for the first class, Newell/Simon's GPS (1961) a representative for the second.)

Symbolic approaches employ modal calculi for the description of 'world states' (see Carnap (1967) for a pre-computer attempt of this kind) and for the mechanizable derivation of consequent 'world states' under hypothetical sequences of applications of the various defined rules. The problem-solving process is thus translated into a process of finding a sequence of rule applications which will transform the description of the present 'world state' into the supplied description of that 'world state' which is to be regarded as the goal state.

A number of efficient symbolic-approach problem-solvers (often called 'question-answering programs') have been developed during recent years (cf. Pople 1972). But we cannot simply go and use these problem solvers: we must define a comprehensive data base of deduction rules and facts, before we can make other than trivial use of these problem solvers. No one has, as yet, defined a data base for general use which contains a vast number of common-sense deduction rules and basic facts about our world although all symbolic-approach problem-solvers require such data in addition to problem-specific rules and facts.

Simulation approaches do not differ much from the symbolic ones in the representation of rules and facts, this difference is often exaggerated. Syntactically, there is little difference between "put x y z" and "has x y z". Semantically, the effect of having written "has x y z" is the explicit storage of "has x y z" in the data base; the effect of having written "put x y z" is the ordered storage of the value z under the indicator y on the property list of x; the phrase "put x y z" or the term "x y z" are not explicitely stored.

The essential difference between the two approaches lies in the effects of rule applications. In symbolic-approach problem-solvers, applications of a rule to a description will produce a new description without removing the old one. In simulation-approach problem-solvers, application of a rule in a given state will produce a new state which *replaces* the old one.

The advantage of the simulation approach over the symbolic one is obvious: the number of states of a simulation model is at any time exactly 1, while the number of state descriptions stored in the data base tends to increase with each rule application. But this advantage implies simultaneously a disadvantage: Once we have applied a rule in a simulation model, we cannot recover the state that was. The symbolic-approach problem-solver, in contrast, is capable of 'hypothetical reasoning'; it can try out alternative sequences of rule applications because the original description is never removed or replaced.

If the simulation model were very small, it would, of course, be possible to explicitly save *copies* of the model in specified states, which would make it possible to abandon the model when a sequence of rule applications has put it into an undesirable and unpromising state, and then to *restart* with a copy of the model as it was before. Unfortunately, this is a clumsy solution for more than very few copies if the model is large. However, there are possibilities to implement 'hypothetical-reasoning ability' in large-scale models also.

Does the disadvantage overweigh the advantage of the simulation approach over the other one? How important is it to be able to perform hypothetical reasoning?

Hypothetical reasoning is the reason why we have science, in the first place. It allows us to foresee the consequences of our actions of inaction and to seek to avoid undesirable and unpromising future circumstances while there is still time to look for alternative courses of action and counterbalance unfavorable trends.

In the robot as problem solver, the purpose of using hypothetical reasoning is analogical. The robot is to be able to 'regulate' *before* unfavorable circumstances are an unavoidable reality. (Thus, he is not to behave like a thermostat, because thermostats begin their regulatory action first when an 'error' (that is: a deviance outside the norm range) already has occurred.)

Hypothetical reasoning is counterfactual reasoning (Rescher 1964) and can therefore also be used for solving such problems as expressed by "if I were him, what would I do in such a case?"

(We suggest that this type of counterfactual object can be modelled by substituting certain prominent features of the other into a copy of the self-image, but leaving the basic personality details unchanged. Thus, "if I were Rockefeller" is to lead to a replacement of socio-economic status in a copy of my self-image, other things being left unchanged. "If I were twenty once more" would lead to a replacement of age in a copy of my self image, but probably also to a substitution or enhancement of the set of friends and acquaintances, and to a change in the set of commitments and obligations.)

The ability for hypothetical reasoning in a robot is therefore highly desirable. But the robots we model need not (indeed, must not) be error-free in their reasoning. It is human to commit errors, and our simulated persons are therefore also to err – not all the time, but sometimes, and especially often (as in real life) when a correct solution is especially important and desirable, namely when a decision has far-reaching consequences. The kind of problem-solvers that have as yet been attempted are, in contrast, completely rational problem-solvers (because they are not to be used for simulation of, but for assistance in, human decision making). We can therefore manage with an ability for *some* hypothetical reasoning, a few 'steps' into the future only, instead of an ability to test many elaborate alternative trajectories. To take an example from chess-playing by computer: Of course, we would wish simulated chess-players to be able to play as good as the best human chess-player occasionally, but it is usually sufficient with much less sophistication. Only rarely will a simulated chess player be one that looks sixteen draws ahead, it will most often suffice with his being able to look ahead two, three, or four. Such more modest abilities are not impossible to implement also in simulation-approach problem-solvers; their costs (in terms of computing-time increases and/or storage-

requirement increases) are probably not significant enough to consider a switch of approach for that reason.

The symbolic approach seems 'smarter' on the surface: All you need to do is to submit small bits of information in any order you like, and the data-base monitor takes care of the ordering. But when it comes to specifying behavior rules, we soon find that we have gained nothing: We must still be very explicit about preconditions and consequences, exactly as we need to be when we write a computer program. As a matter of fact, eventually we even find that writing a program is *easier* because of better means of referencing variables and of controlling the flow of computation.

Besides, the symbolic approach implies essentially harder problems regarding the artificial problem-solver's 'understanding' of what the reasoning is about; a simulation approach problem-solver, in contrast, comprises a model which is the very meaning of what we speak about when we speak about facts, and the computational effects (upon this model) of the 'evaluation' of instructions or rules are the very meaning of these instructions or rules.

We have chosen the simulation-approach for the problem-solver component of the atman system. (But a symbolic-approach problem solver is meant to be made part of the repertoire of it, in order to simulate hypothetical reasoning and verbal communication, when an adequate database has been accumulated.) Our problem-solver design resembles superficially that of the GPS, but it is not derived from the GPS. (As a matter of fact, it developed out of experiments with linguistic production rules.) We shall describe our design in the next section.

7.2. The Jig Processor

This section describes the Atman Monitor (cf. Volume 3), but for pedagogical reasons not exactly as it is implemented, rather as it was originally planned. This description is therefore a *simplification* of the implemented version as it is described in Volume 3.

7.2.1. The Definition of Jigs

There are two types of jigs: 'basic' and 'non-basic' ones. Non-basic jigs generate other jigs and put them on a list called 'jig queue' or 'task stack'. All jigs which do not add other jigs to the jig queue are basic; they only update the property list of some agent. The jig queue is unique for each agent.

We shall speak of 'pushing' and 'popping' tasks or jigs, and of 'task stacks' or 'jig queues'. A task stack or jig queue is simply a last-in-first-out

ordered list of tasks or jigs.

When we add a task to this list, we *push* that task; when we remove and simultaneously obtain the last pushed task from the task stack, we *pop* that task.

A jig is a module that comprises the following parts:

- A module *name*
- An *argument* list
- A specification of *preconditions* for the applicability of the module. (For instance, "B knows of C" or "D trusts E to at least 50 percent" or "the general economy index is approximately 0.3".)

- A specification of the temporal duration of the task-solving behavior defined by this module.

(For instance, looking for a job is a matter of days, weeks, or months, more rarely one of minutes, hours, years, or decades. Making a phone call is usually a matter of minutes. Trying to succeed in a career is usually a matter of years or decades, etc.)

The duration of a jig may be specified either as a numerical constant or as a function which computes a numerical value (and thus enables differentiations according to current circumstances).

- An optional indication of the degree to which the task-solving behavior defined by this module excludes the simultaneous performance of other behavior by the same individual.

We call this index 'jig intensity' or 'attention'.

(In case this indication is missing, a default value will be assumed which is in direct proportion to the specified temporal duration: short-term activities are assumed to be highly exclusive, while long-term activities are assumed to be decreasingly exclusive.)

- The intensity of a jig may be specified either as a numerical constant or as a function which computes a numerical value (and thus enables differentiations according to current circumstances).
- A specification of *direct effects:*
  This is either a definition of a property-list updating routine (in which case the defined module is a basic one), or a list of other task modules, which are to be pushed (in which case the defined module is non-basic).
- An optional specification of immediate 'side-effects' which we wish not to treat as separate tasks; for instance, behavior-associated affects and other physiological changes, or general or directed messages, or the formation and registration of beliefs, skills, attitudes, or commitments.

- An optional indication of the instrumental value of the task module: that is: an indication which, while trying to plan or to analyze behavior, allows individuals to infer which task modules might be appropriate in certain situations.
  (For instance, "bribe b" might be adequate in some situations when one wishes b to do one a favor.)
- An optional indication of the *priority* of the task when it is on some individual's task stack. When a priority value is given, the usual order of task resolution, namely the order of their having been pushed, is overridden.
  The priority may either be a constant value or a rule. The rule is evaluated at pushing time.

7.2.1a Comments

Several things are worth noting:

That it is extremely easy to extend and to differentiate the definitions of jigs;

That we make use of a (non-strict) hierarchical ordering of jigs, in order to be able to take advantage of common elements in many behavior sequences.

This, however, does not prevent us from allowing recursiveness in calls of jigs. An individual may, f.i., find that in order to form a coalition (a,b,c,d) it is recommendable or necessary to form a coalition (x,y,c,z) first.

Jigs can be used both for the deduction of concrete and task-relevant behavior and for the induction of plans and motives.

(For planning, however, it is in practice more favorable to construct a separate situation-classifying tree with the help of the induction-clue lists. This can be done in a distinct jig-learning phase prior to the proper simulation.)

7.2.1b General vs. Special Jig Properties

It is possible to override the general jig properties and to use specific properties instead. We may, for instance, wish to modify the priority of some jig in a certain situation, or to change the scheduled jig duration (especially when a jig's execution has been interrupted). Or we may wish to supply specific functions that produce side-effects.

The replacement of standard properties by agent-related ones is easy to accomplish if such agent-related properties are stored on the jig's property list under the name of the agent, and if the jig-evaluation first seeks for specific values and takes the standard properties only as default values.

7.2.2. The Processing of the Jigs

"Processing of a jig" means the evaluation of a jig; that is: the execution of a task if it is basic, or the resolution of a non-basic jig into a list of other jigs; these latter modules are processed further as long as the intensity limit is not exceeded.

7.2.2a. Individual behavior

The jig processor's surface structure is very simple. We shall first specify this 'naive' processor structure before we, in the next section, give the slightly less transparent specification of the jig processor's detailed structure with its many surface-structure breaking rules.

(A1) Pop the task stack to obtain a list. The first element of this list is a module name, the remainder of the list is the list of arguments.

(A2) Check all conditions mentioned in the popped task module M. If any condition is not fulfilled, go to A1.

(A3) The individual's property list contains an indicator "attention"; we associate it with information of the form "(M, S)", where

M is a jig name,

S is the time of initiation of the behavior defined by M.

The indicator "attention" may be associated with several such pairs at the same time if the sum of the referred-to modules' attention values does not exceed 100.

(A4) If the task module called M is marked 'basic', go to A5. Otherwise push the list of subtasks into the task stack in reverse order. Go to A1.

(A5) If the module is marked 'basic', execute the routine attached to the module under the indicators "expr" or "fexpr".

(A6) Return control to the monitor's top loop.

7.2.2b. Individual Behavior: our Implementation of the Jig Processor

However, the jig processor has a somewhat more differentiated manner of operation:

(B1) Let the currently focused-upon agent's accumulated attention (according to A3 above) be E. Let the currently focused upon jig's intensity be I. If E + I exceeds the standard intensity level (which is set to 100) by more than 50 %, return the value "Occupied". However, if E alone exceeds 100 (intensity degrees), and I does not exceed 1, or if its duration is zero, continue to (B2).

(Comment: This last rule is meant to ensure that trivial tasks still can be performed, and that scheduling jigs can be acknowledged.)

(B2) Test all jig-specific preconditions and domain definitions. These constraint definitions are to be formulated in such a way that their evaluation yields the value "Okay" if conditions are met, "Never" if it can be deduced that the conditions cannot ever be fulfilled in the future (or at least not within the relevant future), for instance, because the person is beyond a certain age, or of the wrong sex, etc., and "Wait" if the conditions are not met but can be expected to be met in the relevant future.

(B2A) "Wait" can be changed into "Never" if the focused agent's jig-queue is very long whereas the jig-priority is rather low. (The agent can in such cases be assumed to simply ignore less important tasks).

(B2B) Return the value obtained in (B2) or (B2A) unless it is "Okay". ("Return" means here: "Return to the top loop".)

(B3) Update the agent's 'attention'-list. (See A3.)

(B4) If the jig duration exceeds 1 time unit, store on the jig's property list, under the currently focused agent's name, the jig-duration value minus 1. (We call this agent-and-jig specific value 'the remaining duration'.)

(B4A) Furthermore, still if the jig duration exceeds 1, store the jig name on the agent's property list, under the indicator 'ongoing'.
(Comment: When the agent is focused for the first time during a time unit, the monitor updates all remaining durations which were stored according to B4 by subtracting 1. Negative results lead to the removal of the jig name from the agent's 'on-going' list.)

(B5) Evaluate the jig's 'kernel', namely the function which shall produce the intended direct effect. (If the effect is, or includes, the pushing of new jigs, then a test will be made whether any of these new jigs is to interrupt on-going jigs (that is, jigs with durations exceeding 1 time-unit) because it has higher priorities.

(B5A) If an interruption occurs, each of the interrupting jigs (in priority order) replaces one of the ongoing jigs. The replaced jigs are usually returned to the agent's jig queue, but special interruption rules may be added to a jig; such interruption rules will then define how the processor is to procede.

(B5B) The priority of a jig of duration exceeding 1 time unit can be defined to be dependent upon the length of the remaining duration. Such a rule takes thus saturation effects into account.

(B5C) When the jig's kernel has been evaluated, the returned valued is "Okay". The returned values can be used for steering the sequence of processing of jigs in other jigs. (We can, f.i., wish to make the

triggering of some action depend upon the success of some specific earlier action.)

(B5D) The 'kernel' of a jig can be made to be dependent upon the length of the remaining duration. We can thus differentiate on-going behavior from time-step to time-step.

7.2.2c. Aggregate Behavior

When we wish to simulate formal organizations or other social systems with differentiation in capabilities of the members, it can in some cases be recommendable to let individuals become modules on the aggregate-simulating level. This means that one chooses to regard individuals merely as tools or task-solving operators which the aggregate selects as seems best to it. Individuals are simultaneously tasks and task-solvers in that case; the total aggregate becomes a 'macro-individual' instead.

8. Social Interaction

8.1. Face-to-Face Interaction

Face-to-face interaction has not been modelled very often or very extensively in sociological literature, and even more rarely for simulation. Gullahorn/Gullahorn (1963), Brightman/Kaczka/Shane (1969), Loehlin (1968), Bråten (1968), and Krarup (1972), are among the approximate dozen of sociological simulation studies of face-to-face interaction that we know of. Dutton/Starbuck, in their very comprehensive survey of Computer Simulation of Human Behavior(1971), also point out (p 243) that the lack of interaction simulation studies (not *only* of the face-to-face type) surprised them since it is "rather inconsistent with both the interests of social scientists and the comparative advantages of computer simulation" ... "Models of interaction are difficult to formulate verbally and mathematically, because Alice and Betty may perceive the situation differently, and because there is likely to be a difference between what Alice intends to say and what Betty hears Alice saying. Computer simulation is probably the only method now available for representing social interaction realistically." Dutton/Starbuck then try to explain the lack of interaction studies (p 243–244).

They seem to suspect that individuals are not considered worth studying, and/or that individual behavior is believed to be unpredictable, and/or that researchers do not wish to deal with 'soft' data. Other researchers shrink from the complexities of interaction studies, they suspect further. They also point to the fact that most human interaction occurs in natural language and that the prospects of being forced to cope with natural-language processing tasks are likely to be deterrant.

With regard to non-simulation studies, Goffman (1956, 1961, 1967, 1970) has studied face-to-face interaction extensively and from many perspectives, but there are also a number of more particular studies (often of a 'popular-science' type), such as Berne (1964), Chapman (1968), or Fast (1970), which predominantly concern face-to-face interaction. (Cf. also Argyle 1969).

Less systematic studies can, of course, be found in fiction, or in biographical reports on particular interactions. Especially in novels and plays are descriptions of face-to-face interactions ubiquitous. Our ultimate

goal ought probably be to have become able to generate novels and plays by computer; that would ensure us of the generating model's face validity. Regardless of how often we in fact would *print out* such descriptions, it would be extremely valuable and reassuring to be able to simulate with such detail and adequacy. How else, for instance, can we ever simulate the difficulties of an immigrant, or of a discharged prison inmate, to become socially integrated into our society? In fact, how else can we ever really understand 'how the other half lives' (no matter which half we belong to)?

By the way, we are also certain that a comprehensive model of such great descriptive detail would significantly reduce the amount (and change the quality) of empirical data needed for testing hypotheses, because the model can itself account for fundamental constraints on behavior and developments and only requires information on 'exogenous' events (that is: events that are generated by processes which the model does not simulate).

8.2. Entering a Context

Self is not damned to forever remain in those contexts into which our simulation initialization happened to put him. Of course, he must always be in exactly one basic physical context (for instance, leaving home for office, implying leaving the family and joining the group-of-collegues). Only occasionally, however, will Self move into a social context without preparation. Self has usually either been in that context before, or he is personally introduced to it by at least one member of that context, or he has been asked to join, or he has (formally or informally) applied for membership.

The more often Self has been in a given context lately, the more probable will it be that he will return to it; but we shall not simulate inter-context movements on a purely probabilistic basis. We shall instead require that Self also has motives or reasons to join or to leave at a certain moment (for instance, because work starts at 8 a.m.).

The better Self is acquainted with some Other, and the more compatible they are, the more likely is it that they also will be acquainted with many common contexts; furthermore, it is then also the more likely that Other introduces Self into a new context, or vice versa.

However, Self's average ease of integrating into new social contexts is a personality variable which probably is background- and experience-

dependent. Self's age is another factor which influences the context 'explorating' extent: Very early in life, Self's world is rather limited, not least because parents and teachers keep close supervision and effectively inhibit contacts with large parts of the adult world, especially with other subcultures than their own (for instance, in order to keep their children from picking up 'bad language' or 'fancy ideas').

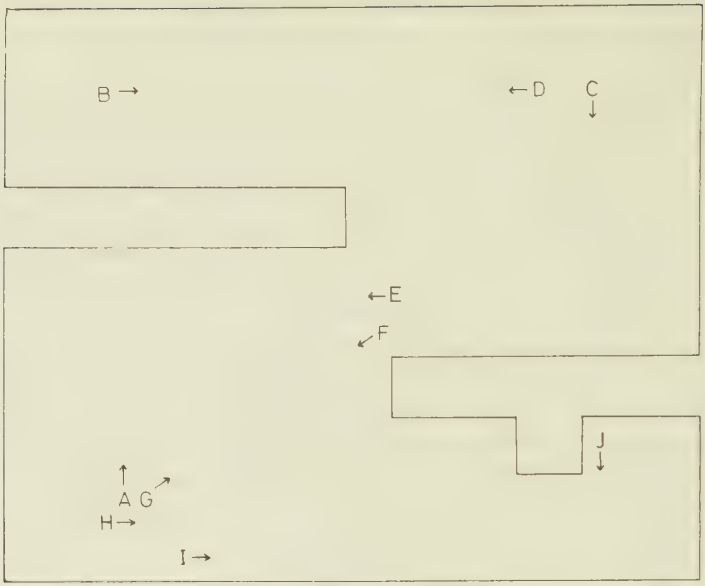
During adolescence, in contrast, will Self tend to be extremely explorative. After having formed a family, Self will again tend to become less explorative, partly, at least, because Self's family responsibilities inhibit other intensive social commitments.

Some social contexts will be very fuzzy with regard to membership, imposing few constraints or obligations upon their members (for instance, a department store's customer-context), while others will be very distinct and exclusive, making high demands upon their members (for instance, the same physical department's store's staff context). It is the exclusive type of social contexts which usually demands applications for temporary or permanent membership.

8.3. Looking and Seeing

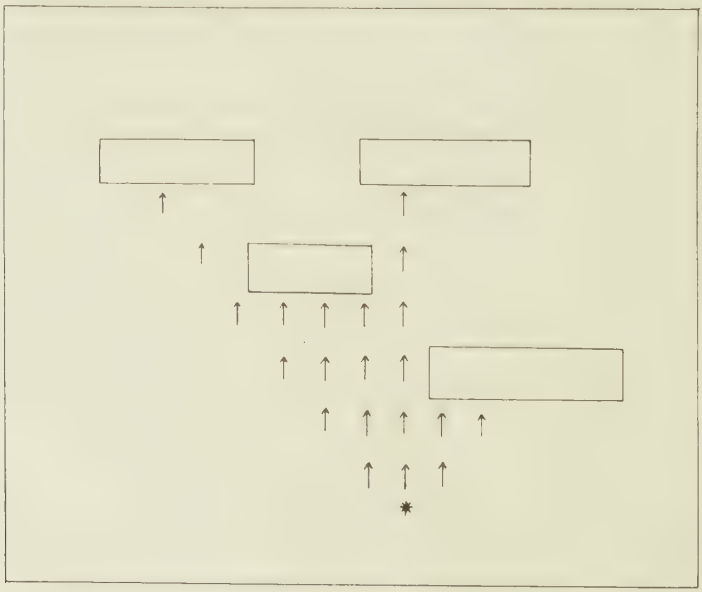
The introduction of the conception of 'looking' into a simulation model has the consequence that a universal communication network within the context, which connects all members simultaneously, becomes a rare feature. The direction into which people look determines what they will see; they can usually not simultaneously overlook a whole physical context (unless the context is small and they stand in one corner, for instance).

Assume, f.i., a situation such as illustrated by figure 8.3a:

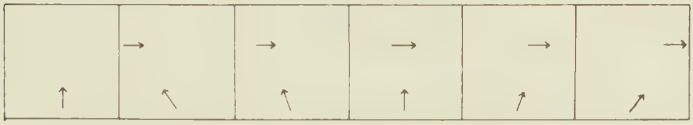


If anything should happen to J, no one could see it. A, G, H and I can be seen by F (assuming the distance is not too far and that the arrow indicates the middle of a 90 degree segment); G sees E, F, D.

It is difficult to define Self's field of vision verbally and we shall therefore only give an example (figure 8.3b):



'Looking at' will be assumed to have social consequences: If Self 'looks at' Other and Other at Self, we shall assume an increasing readiness for social interaction if they continue to 'look at' each other also during the next moments. Letting arrows simultaneously indicate the two agents' positions and their looking-directions, we can easily illustrate two significantly different situations (see figure 8.3c):



This would be a situation where Self is a young man sitting on a bench in a park, for example, watching a girl walk by who ignores him. Imagine instead a similar situation where Self can keep eye-contact (figure 8.3d):

Elevators are typical for physical contexts where eye-contact is avoided because there is no other reason for social interaction, unless one is ac quainted, of course. Train compartments are other such physical contexts, but in the course of longer journeys people often find it more comfortable not to be obliged to avoid eye-contact (especially if they do not wish, or have nothing, to read) and they will instead signal readiness for interaction by no longer looking away when they meet a gaze. (Interaction needs then not be verbal, but may be restricted to a smile.)

Of course, Self can draw Other's attention upon himself (that is: Self can make Other look at him) by speaking to him or touching him. But there are conventional restrictions against doing so freely when Self and Other are not acquainted.

Even *if* Self and Other are well acquainted, there are conventions against changing Other's looking-direction. Other and Third may, for instance, stand in a corner and converse, indicating by their spectacular isolation that they do not wish to be interrupted.

While Self looks around a physical context, we must keep record of which persons he has as yet seen, in order to know how Self perceives his situation. (After all, Self may enter a physical context and fail to detect a

friend he would have wanted to meet there.)

The looking-direction may usually not change more than 90 degrees from one time point to the next, but changes will sometimes be at random (up to 180 degrees) into any direction. Sometimes they will be restricted, or unrestricted but systematic. Movement and posture also impose restrictions. We shall discuss these next.

8.4. Movement and Posture

Self can be assigned a *moving-direction*. As long as any moving-direction is given, Self can not look into the opposite direction. The moving direction, like the looking-direction, must not change more than 90 degrees from one moment to the next, and it may also change at random, or with restrictions, or unrestricted but systematically.

At a cocktail-party, for instance, if Self knows no one and believes to be relatively unwatched, he may stroll around almost at random, only avoiding to bump into people or objects. If he believes to be watched, he will probably move more systematically, for instance, along the wall, pretending to study the pictures, because he does not wish to admit that he is not socially integrated in this context. It will, of course, be impossible to account for such details in large-scale simulation runs, but in simulations of small milieus, and especially of dyadic behavior, it is precisely such details which can control the social process. However, we shall here not be concerned with other than such principles which we believe to have relevance at least in medium-scale simulations such as of a small firm, or a department, or an office landscape.

Alternatives to moving are standing and sitting. Standing is assumed to be directionless because a person who stands can turn freely and look around. Sitting is directed, because once a person sits on a chair he can usually not turn as freely but has only an angle of vision of about 180 degrees. When Self is sitting, interaction is assumed to be possible with immediate neighbors at both sides and in front of Self (that is: five persons maximally in the chessboard-patterned context maps which we as yet have assumed, if we do not allow two or three persons to occupy the same cell).

8.5. Internal-State Analysis

We have, as yet, paid little respect to Self's present mood, needs, intentions, beliefs, hopes, expectations, attributes, commitments, or physiological state, factors which are less visible constraints on particular face-to-face interaction instances than those we have already discussed.

We shall call Self's analysis of his own internal state '*internal state analysis*'. This analysis is meant to result in holistic conceptions of Self's internal state.

Self may, for instance, ask

- Am I hungry?
- Am I thirsty?
- Am I tired?
- Do I feel pains?
- Do I freeze?
- Am I warm?

If all questions are answered in the negative, Self can tell himself that he is 'comfortable'. Otherwise, he needs to act in order to remove the discomfort, unless tolerating the discomfort is part of a plan.

Or better, instead of giving yes/no answers, Self can reply with a number between 0 and 100, where 0 stand for 'definitely no', and 100 for 'yes, very much'. Summation over the six reply values yields a 'discomfort index'.

Self can continue and ask, for instance,

Do I worry about

- a performance I have to present?
- a task to be solved soon?
- my looks?
- my economy? My job?
- my health?
- something I've done or said?
- a friend's well-being?

Again, if all answers are negative, Self can tell himself that he 'feels secure'. A person who feels secure and is comfortable is, of course, likely to behave differently from a discomfortable and/or worried person, he will perceive considerably more selectively, and his interactions will have a bias. (He will, for instance, tend to tell everybody about a funny pain he has in his chest in order to get reassurances that others have survived similar pains quite well and that he therefore needs not worry).

Self can ask whether he is in an aggressive nood, a lazy mood, or op-

timistic, pessimistic, sceptical, happy, bored, content, elated, excited, frustrated, grieved, impatient, irritated, relieved, for instance. And finally, he can inquire which expectations he has regarding the situation he will meet: does he have preconceptions about the type of situation? (For instance, will it be a business conference or a birthday party? Will it be formal or informal? Will it be a predominantly 'instrumental' or predominantly 'expressive' situation?) and if he does happen to have such preconceptions, does he expect to be formally or informally obliged to demonstrate respect/inferiority (or contempt, ability, familiarity, solidarity, innocence, etc.) explicitly towards anyone, or to show it implicitly?

We are not sure whether these questions about expectations really shall be made a part of the internal-state-analysis preceding an actual situation analysis. Of course, in order to be able to deduce feelings of surprise or disappointment we must be able to point to a discrepancy between expectations and the actual situation, but such expectations can possibly be obtained much earlier, being then still able to influence Self's determination to face that situation or to avoid it if he can.

Early preconceptions about future situations allow Self also to prepare himself, for defence or for attack.

8.6. Situation Analysis

Whenever a simulated person is confronted with a simulated social phenomenon, he must analyze it and 'understand' it in order to be able to cope with it adequately, and that means that he must be able to perform psycho-socio-economical analyses.

The simulated person or robot ('Self') is thus confronted with the same problem as his creator, namely to find invariances (that is: structures, constraints and/or regularities) in the social processes he studies. The creator's conceptions can therefore also be made to be the robot's, and their operationality and adequacy can be tested in the simulated psycho-socio-economical reality.

A most general formulation of the problem we face is the following: Self is at each time point in a particular situation; Self needs to analyze his situation in order to detect and recognize structural features which can serve as clues regarding what *type* of situation he is part of and/or what type of behavior is appropriate for Self. (Self's personality, attitudes, commitments, beliefs, and long-term goals are assumed to be given and relatively fixed during any given short time interval).

Such *situation analysis* can, of course, be performed on many different

levels of detail and with concentration on various aspects: we shall, in particular, distinguish between socio-psychological situation analyses ('micro analyses') and socio-economical ones ('macro-analyses').

We can, in principle, follow ordinary textbooks on social psychology and on economics/politics/macro-sociology in their listings of the repertoires of their sciences' particular situation-analysis aspects and methods (that is: *situation-analysis stereotypes*). This is a consequence of the above-mentioned assumption that a simulated robot and his creator face quite similar situation-analysis problems in their respective 'realities'. On the other hand, it is erroneous to conclude from this that we now are trapped in an infinite loop, since we have created the simulated robots *in order to* be able to improve our own situation-analyzing capabilities. The fallacy lies in the assumption that the simulated robots need to make perfect situation analyses in order to be of value as tools in our own situation analyses. But that is not the case: If our simulated robots use socio-psychological situation-analysis methods exactly as an ordinary social psychologist would, f.i., we can still expect to make better situation analyses with the help of our own simulation than that social psychologist would. Why? Because, as yet, it is a fact that everyday people *at best* have a social psychologist's situation-analysis abilities; and, after all, we attempt to simulate the *actual* behavior of these everyday people in order to improve our insight into situation-inherent structures and expectable consequences.

We said that we could use textbook listings of what we can interpret as sterotype-repertoires, but, of course, since textbook authors do not tend to have an unified and operational view, we must probably regroup topics in order to obtain a collection of situation-analysis schemata which can be hierarchically ordered with regard to the references they make upon one another. If such an ultimately hierarchical order could not be found, it would be impossible ever to base the analysis upon (possibly hierarchically arrived-at) fixed 'terminal' values and we would keep on analyzing forever.

As an example of which aspects of general social situations at best are mentioned in textbooks on social psychology, we shall look at the (randomly selected, but in our opinion not atypical) textbook by Antti Eskola (1971, in Swedish). The following topics are such that we can interpret them as directly usable schemata for situation-analysis purposes; and yet, they are unusable in computations because the listing lacks an appropriate ordering:

(1) Group structure
  (1A) Power and power distribution
  (1B) Attraction
  (1C) Communication

(2) Social 'institutions'
  (2A) In general:
    (2A1) Social norms
    (2A2) Social roles
    (2A3) Education
    (2A4) Social 'institutions' in general
  (2B) Economical 'institutions'
    (2B1) Types of economic systems
    (2B2) Types of roles within economic systems
    (2B3) Achievement motivation
  (2C) Political 'institutions'
    (2C1) Democracy
    (2C2) Machiavellism and authoritarianism
  (2D) The family
  (2E) Education
  (2F) Leisure 'institutions'
(3) Social Processes
  (3A) Socialization and personality
    (3A1) Inherited vs achieved personality features
    (3A2) Deprivation
    (3A3) Age
    (3A4) Attitudes
  (3B) Social control
    (3B1) Social deviance
    (3B2) Social control
  (3C) Social change
    (3C1) Technological change
    (3C2) Innovation diffusion
    (3C3) Attitude change

Our situation-analysis schemata are to be defined in such a manner that their application to a given situation results in a specific measure. A complete situation analysis is thus a hierarchy of measurable computations; each basic measure reflects only a few situations characteristics, but these can then be used for the derivation of higher-order measures (also called 'indices'), etc. The result of a situation analysis (the 'situation descriptor') is either a single measure or a list of measures. We prefer to work with the latter, more differentiated, form of situation descriptors.

We shall furthermore assume that not all schemata necessarily define *numerical* computations, but that some of the computational results which we have called measures may be *names* obtained through a selection process.

It would probably be wrong to assume that *all* situation analyses result in numerical measures. For instance, we may wish to define a schema which merely tests whether there is an occasion for a *chat* on no particular

topic at all. In that case, we would probably only formulate a few conditions which constrain the selection of a potential chatting-partner, and we would eventually identify him by his name.

In contrast to most textbooks, we shall base the development of our collection of schemata not on very abstract conceptions but upon an attempted reconstruction of situation analyses in everyday life. Model-implementation considerations will be discussed in parallel.

When confronted with, or rather embedded in, a particular situation, Self's first analyzing step must be to recognize which *type of context* he is in at present. We want namely to assume that we have specified, for each all *other* types of questions regarding a situation, a list of contexts in which questions of this particular type (for instance, about relative economical influence) are relevant (or irrelevant, whatever is more convenient).

We said before that Self performs his situation analysis in order
(1A) to detect acute and potential dangers in his body, his status, his personality, his environment,
(1B) to discover immediate or developing possibilities for the improvement or enhancement of his physical comfort, security, socio-economical status, social insight, social integration, intellectual capacity, skill, amount of freely disposable time,
(1C) to recognize occasions for performing certain actions which Self has a (possibly perpetual) wish to execute.

This specification of purpose is very general and abstract, and it is therefore necessary to indicate (2A) how self is to recognize the positive and negative characteristics of a situation, (2B) which types of reactive behavior the situation 'allows' (or even 'recommends'), and (2C) which are the desired actions and what is specific for these occasions which enable Self to perform the desired actions.

Let us start with 2C and assume that these beforehand intended actions are included, as action jigs, in Self's jig queue. The occasions which enable Self to evaluate an action jig are, quite ordinarily, defined by the jig's evaluation preconditions.

Problem 2B can be coped with similarly. Given a situation descriptor, it can be referred to in jig preconditions.

Problem 2A is probably impossible to solve as long as one attempts to arrive at, and work within, objective situation descriptions only. (Most robot problems we know of at present, however, seem to assume objective situation descriptions exclusively.) We shall try to derive both objective *and* relative situation descriptors. For instance, we can find that Person 3 is in the context Home 1 at present (=objective description) and that Person 3 is in the same context as Self at present (= relative description). The

relative descriptors can be made to imply indications of the positive and/or negative character of a situation; comparisons of relative descriptions attained at consecutive time points allow the deduction of indications regarding positive and/or negative trends of development. The *objective* descriptors are to be used during situation analysis also; however, they are only auxiliary descriptors. For instance, let Self's objective environmental status be given. Now we wish to know whether Self's *relative* status is higher in context C1 than in context C2; the relative status is easiest to compute if we know the objective economical status of each and all members of C1 and C2.

This last example can also serve to illustrate that it is easy to specify the meaning of 'goodness' or 'badness' for a standardized relative descriptor, while it is much more difficult for a non-standardized objective descriptor. (Or another example: Self has had a wage increase by 9 % during the last year; thus has his objective economical status increased. But this *may* be misleading. If the quantity-weighed price increase average during the same years was 10 %, for instance, his *relative* economical status has in fact deteriorated.)

In our simulation model it is, of course, trivially simple for Self to identify the type of the context he presently is in. (Remember that Self can simultaneously be in *several* contexts, whereof one physical).

The second situation-analyzing step can then be made to be also rather trivial, namely to obtain from the database the list of norms and expectations which we have specified to be frequently connected with the actual context type. These norms and expectations, in turn, will probably be associated with individual preconditions; some of these preconditions will possibly refer to situation descriptors, and the names of situation-analysis schemata which produce these situation descriptors must therefore be included in a list of all situation-analysis schemata to be applied during Self's analysis of his present situation. (We shall call this list 'Self's current schema-list'.)

Self's third situation-analysis step consists of a scan through the global list of all defined situation-analysis schemata. Hereby a test is made which is to inform on whether each particular schema is applicable to Self's present situation. The names of all applicable schemata are added to Self's current schema list.

When this third step is completed, Self needs to order his current schema-list with regard to schema-interdependencies. (As we said earlier, interaction-analysis schemata may presuppose the results of certain other interaction-analysis schemata.) Then he may start to apply the first schema from his current schema-list to his present situation.

8.6.1. Situation-Analysis Schemata are Jigs

The application of situation-analysis schemata modifies in no way Self's given situation. It only produces a situation descriptor by evaluating the schema definition. This 'evaluation' *may* be supposed to take some simulated time (that is: schemata may be given an evaluation duration exactly like jigs). Situation-analysis schemata may also be given evaluation priorities (which could be used to make situation-analysis step four, namely the ordering of Self's current schema-list, superfluous) and intensities (which may lead to incomplete situation analysis when Self is under stress). We can eventually look upon situation-analysis schemata as merely a particular type of jigs. If we render situation-analysis step 4 superfluous, as indicated above, and remove the schema-list ordering, we can therefore assume that Self's current schema list and Self's current jig queue are identical. We shall make this assumption henceforth because it simplifies our modelling of situation analysis.

8.7. Verbal Communication

In section 7, when discussing the problem-solver designs, we reviewed the advantages and disadvantages of the symbolic approach and hinted, in designing our own problem-solver, that we intend to include a description-handling subsystem in the total system eventually.

Verbal communication, which is such a significant part of all social interaction, can namely not be modelled except by a description-handling database-monitor. A message such as "I'll meet you in the garden tomorrow afternoon at four" can still be translated into a pragmatical scheme: a memory entry indicating that Self is to meet Other at a certain spot and a certain time (perhaps also for what purpose, in what mood, etc). But phrases such as "I almost failed to remember that I was to meet you here today", or "Don't tell me you really believed what he said" carry too *subtle* messages to be reflected in a simulation model's state.

The important question is naturally whether we must ever expect that Self is to generate, to receive and understand, and to remember such subtle information. In our opinion we must. As a matter of fact, if Self could handle such subtle information symbolically within a simulation model, the total system would have an enormous capacity, because Self and Other could debate intelligently within the simulation model and try to persuade or convince one another, to obtain advice from the other, or to gossip about third persons. It would, for instance, become possible to simulate the effect of a lecture upon a given group of listeners' belief and value systems.

In a pure simulation system can such effects at best be only very crudely approximated.

The ultimate goal for symbolic information processing within our simulation model must be natural-language processing, of course, but within our foreseeable future we seem to have no chance of tackling that problem effectively and systematically.

Anyhow, we must at least come up with a provisional means of expressing and processing *some* types of states of affairs symbolically. Rhetoric capacities are, as yet, unattainable, but Self must be made able (A) to transmit simple messages, (B) to remember descriptions of at least *some* types of situations, and (C) to derive 'pragmatic meaning' from such messages and descriptions (that is: to be able to let his course of action be adequately influenced by the information they carry).

Observe that Self already in a simulation model can interpret behavior rules of the type "if x then do y" (jigs are formulated that way, after all). He can even translate descriptions such as "when A was in situation x, he did y, and z happened as a consequence" into action suggestions, by means of a fixed translation scheme. But to deduce an appropriateness index for some potential action from a large number of rules such as "Most x have a tendency to prefer y to z" or "It is said that there is only a remote chance that w happens when s is the case" is beyond the capacity of a simulation-approach problem-solver, especially if Self is also to pay attention to the credibility of his information source.

The crucial difficulty of implementing a verbal-communication capability lies not in finding a way to transcribe natural-language phrases into formal-language sentences, but to find for such a formal language an interpreter which can make Self-relative interpretations of a sentence of that language. That means that the interpreter

(A) must be 'aware' of Self's current situation,

(B) must be 'aware' of Self's current needs, tasks, and intentions,

(C) must be able to judge whether a sentence (as a message) at present has relevance for Self, and if so, in what way.

We know of no study of this kind of a 'pragmatic interpreter' which relates its sentence interpretations to the states of a simulation model. But it seems to us somehow obvious that the interpreter of a sentence must have a picture of the speaker, of the listener, and of their world regions in his artificial or natural mind while trying to understand the 'pragmatic meaning' of that sentence. For instance, "I am here" has no complete 'pragmatic meaning' without a conception of who says it in which situation, nor has "I told you so". For that reason, we must make a distinction between a 'generic pragmatic meaning' of an utterance which can be un-

derstood without knowing the particular situation in which the utterance has occurred, and a 'particular pragmatic meaning'.

To give one example: The 'generic pragmatic meaning' of, for instance, "I told you so" is approximately the following: Some Self has told some Other about something which Other eventually, perhaps with some surprise, finds to be the case. Self's remark implies a (perhaps only slight) reproach for Other's disbelief or forgetfulness.

A 'particular pragmatic meaning' is based upon the generic one, but related to a quite concrete, particular situation. The variables 'some Self', 'some Other' and 'something' are valuated. A 'particular pragmatic meaning' of "I told you so" could, for instance, be explicated as follows: Person31 has told Person122 that he ought not to trust Person44. Person122 does anyway, and reports to Person31 that Person44 is not trustworthy. Person31 now reproaches Person122 for not believing Person31's judgment.

An ordinary question-answering system could treat "Self says "I told you so" " merely on the top level and not consider the effect of what Self says. A 'pragmatic interpretation' could for each of the listeners, for instance, imply an interpretation of *why* the speaker said what he did and how he said it. Probably can this interpretation not be made until first the general 'semantic meaning' of the message has been derived, and thereafter the 'particular pragmatic meanings' of the message *as such* (that is: without yet performing a message-reliability analysis) for each of the listeners. The analysis of the speaker's motives for making his utterance is part of a source-reliability analysis, which, in turn, is part of a message-reliability analysis. The complete 'particular pragmatic meaning' of a message cannot be obtained unless a situation-particular message-reliability analysis has been performed.

We are quite obviously up against immense difficulties which we cannot hope to overwin within the next decades unless some radically new approach to the solution of these kinds of problems with 'meaning' is found by somebody. Of course, such a discovery would mean a new complete revolution, perhaps the ultimate one. We believe naturally that it would be wrong to wait passively for what may never happen, but we see, on the other hand, that there are many other of our crucial difficulties which receive far less attention than these language-oriented problems. We feel therefore that we ought to focus most of *our* attention upon those sociocybernetical modelling problems which generally are neglected, postponing the modelling of verbal communication until we can afford to give it undivided attention.

9. Remembering

Even if we choose to postpone the modeling of verbal communication, we cannot quite ignore the necessity to give Self a memory, from which we can match against the preconditions of ready-made jigs which, if 'evaluated', trigger actions.

We need one kind of memory for saving Self's schedule of appointments. The simulation-monitor must during each time interval check whether Self has an appointment booked for that particular time interval. The booking of appointments in the case of clashes with other appointments is an unexpectedly difficult task.

Another kind of memory needs to store information regarding past or future events of significance for Self. If Self, for instance, wishes to remember when and under what conditions he met his wife for the first time, he could save a patterns such as "(event 381: meet1 (person57), place= home20, social context= group-of-friends17, time =75483, purpose= event 252, modality= inadvertently)".

The idea is that we try to save only crude images of particular events, merely specific enough to roughly guide Self's decision-making (as implied in the 'evaluation' of jig preconditions which can ask whether certain memory contents exist, or which refer to particular variable-values that are possibly retrievable from the memory).

Other useful descriptors are "*cond*=" (which labels a condition for a future event to happen, or a reason for why a past event happened or could happen), "*utility*=" (which labels either an estimate of utility or the definition of a function which computes such an estimate), "*duration*=" (which labels the specification either of length of time or some definite moment, after which the event no longer exists (except as a memory possibly)), "*partner*=" (which labels the definition of some interaction partner), "*urgency*=" (which labels a value which is used to determine the relative priority, in the situation given at the specified moment, of triggering this event).

All such descriptor-labeled partial event-descriptions are to be optional

If we let the schedule search be a jig with a certain non-zero intensity, Self may fail to make such searches while he is very stressed. Forgetting an appointment may cause trouble for Self. On the other hand, if Self is afraid of forgetting a certain appointment, he may push a top-priority jig which tests regularly whether the time has come for that appointment.

10. Time

10.1. Time Units

A *time unit* is the interval of time which we choose to regard as the 'same' moment. It is obvious that we in real life never consistently use only one sort of time unit, for example a second, but many. It is not nonsensical to utter "Ten years ago I was in Bombay for a year; that was when my daughter eloped to Acapulco with this fellow Budge Something" and a little later "If I had passed only a moment later, not more than a second perhaps, the pot had hit me on my head". We change time perspective all the time while we talk: "When I was in Tananarive, one day a white man quietly came into the hotel where I was staying and began to crawl about on his hands and knees. Colored staff members assembled around him but hesitated to interfere for a long while . . .".

We believe that an adequate sociocybernetic simulation system ought to allow similar flexibility in the specification of time units. It ought to be possible to specify a simulation of a special system over one year, for instance, to be performed by using time-units of 1-hour lengths during the first five days, then time units of 1-day lengths during the next 25 days, then time units of 1-week lengths during the following 8 weeks, and finally time-units of 1-month lengths for the rest of the year.

In order to enable this, we let one *basic time unit* correspond to, for instance, one minute. Time is counted as the number of basic time units passed since the simulation started. Non-basic time units (for example, a week) are internally transformed into multiples of basic time units. Dates (f.i., the 4th of July of next year) are transformed into the number of basic time units that will have passed up to that date.

We use, on the other hand, also counters of hours (up to 24), days (up to 7), weeks (up to 4), months (up to 12), seasons (up to 4), and years (unlimited), in order to facilitate the use of curricula (for instance, a curriculum for the fourth day of the week, or for the 8th month of the year).

10.2. Time Steps

A *time step* is an increase of the global variable called Time by a positive number n. This arithmetical operation symbolizes the passing of n basic time units. The number n is called the *current time-step length*. When we say that the current time-step-length is 1 day, for instance, while the basic time unit's length is 1 minute, then we obviously mean to say that the current time-step length is 1440 basic time units.

10.3. Time- vs. Event-Triggering of Actions

Our simulation system is both time- and event-triggering: the top loop controls time, but within each time step are most actions event triggered.

11. Multi-levelled Simulation

11.1. Levels of Abstraction

Take any biography, or white-book, or history book, and you shall see that the author sometimes speaks of actions of persons (f.i., "in March 1968, Diana helped create a women's liberation group"), sometimes of the behavior of aggregates of persons (f.i., "in the spring of 1968, students at Columbia turned the American student movement toward revolution", or "The civil-rights activitists who risked, and sometimes lost, their lives in the rural South developed a burning anger for the society which ignored them."), sometimes of the interactions of persons (f.i., "on May 1, 1968, the New York police removed nearly 1000 young activists from five buildings on Columbia's Morningside Height campus.", and sometimes of interactions between persons and aggregates (f.i., "In December, 1964, a group of black militants met with Che Guevara at the Hotel Theresia in Harlem during a visit to the United Nations by Fidel Castro. The militants asked Che what he thought of the possibilities for guerilla war in the United States.")

If we analyzed interactions between aggregates more closely, we would certainly often find that some of the aggregates could be said to be aggregates of aggregates (f.i., "The village's twelve families sent a letter of protest to the Department of Education.").

Of course, aggregates as such cannot ask, intend, prefer, or act, only concrete living beings can. Aggregates of persons are abstractions, aggregates of aggregates (such as 'the village's twelve families') are abstractions of order 2 (that is, double abstractions), etc. There is no exact telling what order of abstraction denotations such as "this nation" or "the multi-national firm HAL" have 'in reality', but within a given morphology we can approximate it. Whenever we say "the description of this system is on a higher level of abstraction than the description of that one", in exactly these words or with obviously synonymous formulations, we mean to say that 'this' system's denotation is of a higher order than that of 'that' one.

But although only living beings can intend, prefer, act, etc., we very often speak as if also aggregates (on any level of abstraction) could, simply because it is practical and usually tacitly understood that the intending, preferring, acting, etc., 'in the end' is done by living beings. Because it very

often is so very practical to let aggregates be agents in descriptions of social systems and social processes, we also want to be able to use them while we work with simulations, for instance, in order to obtain more concise computer outputs (with implicit sociological, psychological, and economical analyses evidently), or in order to be able to communicate with the computer in a concise (that is, not undesirably detailed) manner. Besides, we may also have economical reasons for conducting different parts of our simulation on different levels of abstraction. We may, for instance, wish to simulate one family in maximal detail, but its environment in a less detailed manner; this is obviously an acceptable way to convey a plausible and interesting description of a social system, because otherwise it would not be the universal method used in novels and plays.

This leads us to the idea (which we already voiced earlier) that an adequate intermediate goal for us as simulation-system constructers would be the automatic generation of detailed outlines for plays or novels. If they seem realistic (at least approximately as plausible as novels and plays ordinarily are), one can surely not deny that the employed model has face validity. This intermediate goal has an enormous advantage over the ultimate one (which is to be usable as an instrument for psychological/sociological/economical/political theorizing) by being much more operational; it is easy to see whether one fails or succeeds.

Besides, one *can* use it for being creative without being bothered by the dilemma to either be as uncommunicative as modern poets, or to be banal. Rütsch (1950, p 4) reports that Paul Valéry explained his inability to write novels to root in his aversion against putting trivialities such as "at five o'clock the countess went out" on paper. We understand him very well; it's a waste of time. And yet: it seems that no 'mood' can be conveyed without these trivial details; a concise outline has no 'mood'.

A *completely* automatic generation of a novel or play, on the basis of a more or less detailed outline, is impossible as long as the simulation system does not

(A) have the capability to generate correct syntactic structures from semantic ones without being quite obviously stereotypical;

(B) have the capacity to consider and differentiate behavior according to subtilities in situation interpretations; and

(C) have access to a very comprehensive database containing common knowledge about this world.

(A note for those who are interested in this type of future applications of socio-cybernetical simulation systems: There is very little hope that obstacles B and C will be overwon during the next decade.)

In order to be able to regard aggregates as agents we must supply behavior rules, according to what we said in chapter 3 on agents in general. Each agent's properties must also be supplied. However, in the next section we shall explain how we can avoid to do so in the case of agents that 'really' are aggregates.

11.2. Implicit Sociological/Economical Analyses

It would be very inadequate to use constant property values for any agent. But, on the other hand, we do definitely not wish to be forced to update any property values according to abstract rules which to us do not have face validity. If we did, we would lose much credibility.

We must therefore seek to derive aggregate-characterizing measures from the properties of the components. All measures developed by the group-dynamic 'school' in social psychology are relevant candidates for such descriptors. New measures need probably be devised, such as measures of the relative power of individuals or groupings; of an aggregate's compatibility with another (a measure which, by the way, also can be used as a criterium in a person's 'reference-group' choice); or of hierarchization (that is, lack of democracy). Statistical characteristics such as average income per year, or average age, or homogeneity with respect to one or several member properties, are very easy to compute, of course.

All of these measure computations imply obviously sociological and/or economical analyses. It should in principle be possible to look at any per son or social context and to obtain absolute and relative characterizations of him/her/it, as if we had performed a complex multivariate statistical analysis. This promises to faciliate the analysis of simulation results quite enormously.

11.3. Automatic Abstractions

A desirable property of the simulation system would be if it could start to run on one level of abstraction and switch to the next one above whenever it has accumulated sufficiently exact and reliable measures on an aggregate. Occasionally it would have to return down to more detailed levels in order to 'replenish' the simulation's precision.

However, the higher we rise in the level-of abstraction order above the person-level, the less the face-validity of the behavior rules we employ. A procedure such as the one suggested above can therefore only be justified if we have extensively compared results of simulations of the same social system run on different levels of abstraction, and if these comparisons revealed only small discrepancies.

Sociological, economical, and political theorizing can obviously expect to become almost experimental if such abstractions can be made.

12. References

We have chosen to include only referenced literature in the following list and not to turn it into a bibliography. These references do not give justice to those authors who have influenced us most profoundly, because we, so to speak, have absorbed and dissolved them into our own style of thinking to such a degree that single references no longer can suffice. We think here especially of Ashby's *An Introduction to Cybernetics,* 1956, and March/Simon, *Organizations,* 1958. Bocheński's *Précis de logique mathématique,* 1949, had influenced our ambitions with respect to explicitness already before we encountered the book by Ashby in January 1962, in the course of trying to compile a (verbal) life-trajectory model.

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Sociocybernetics

is a way to model social reality, and man in particular. It is an integrating interdisciplinary approach which explicitly acknowledges the fact that scientific capacity has been essentially augmented through the advent of the computer as an easily accessible tool. Sociocybernetics can be said to be a modern and operational epistemology for the social and behavioral sciences.

Homo Cyberneticus

is an exemplification of how sociocybernetics is to be used for comprehensive causal modelling. *Homo Cyberneticus* seeks to outline a coherent map of everyday life, upon which computer simulations of social-interaction processes can be based. It can also be looked upon as a research program that can systematize and unify research efforts in otherwise quite dissimilar fields, for instance psychology of religion and robotology, linguistics and ergonomics, or literature and futurology. It seeks to thus reassemble man into one whole.

Homo Cyberneticus comprises 5 booklets:

Volume 1: The Simulation of Everyday Life: A Synopsis
Volume 2: Towards an Epistemology of Dynamic Causal Modelling
Volume 3: Heuristic Simulation Programming
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